Fisheries Reports for, 1987-1997 for Colonial National Historical Park, Virginia Prepared By U.S. Fish and Wildlife Service

Colonial National Historical Park
Jamestown-Yorktown-Colonial Parkway

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FISH SPECIES COMPOSITION IN SELECTED STREAMS IN COLONIAL NATIONAL HISTORICAL PARK YORKTOWN, VIRGINIA

July 1987

U.S. Fish and Wildlife Service
Office of Fishery Assistance
White Marsh, Virginia

I INTRODUCTION

A qualitative fishery survey and water quality analysis was conducted July 27-30, 1987 on Beaverdam Creek, Baptist Run, Great Run, Paper Mill Creek and Yorktown Creek, Colonial National Historical Park, Yorktown, Virginia. The survey was conducted by the U.S. Fish and Wildlife Service, Office of Fishery Assistance, White Marsh, Virginia, with the assistance of Park Service personnel. This assistance was provided in accordance with the Memorandum of Understanding between the Park and the Service.

The study was conducted to determine species diversity and was not intended to evaluate relative abundance of any species. Each sampling station included portions of the streams having a pool/riffle habitat to ensure collecting fish species having a site specific requirement. Samples were collected using a gasoline powered back-pack electroshocker having an output of 120 VAC, and a 15 foot seine. Species collected were placed on ice and transported to the Gloucester Point office where positive identification was made (1) and 2) literature cited). Water quality parameters were analyzed with a Hach Model FF2 Test Kit.

Information collected can be Used by the National Park Service as base line information to evaluate changes in fish species composition and water quality which may occur as a result of habitat alteration.

II **RESULTS OF FISHERY** SURVEY

The following is a listing of sample **sites (see** attached map for **locations) and fish species collected at each** site.

Sample Site (see map)	**Fish Species Collected**	**Miscellaneous Vertebrates and Invertebrates Collected**
Beaverdam Creek		
Electroshocker	pirate perch mosquitofish eastern mudminnow tessalated darter pumpkinseed chain pickerel	Many Lined Salamander Sterochilus maginatus Crayfish Scuds Gammarus sp;
Baptist Run		
Electroshocker	**pirate perch** **mosquitofish** **eastern mudminnow** tessalated **darter** pumpkinseed	Many Lined Salamander Sterochilus maginatus Scuds Gammarus sp.
Great Run		
Electroshocker	pirate perch mosquitofish eastern mudminnow tessalated darter banded sunfish	Scuds Gammarus sp.
Paper Mill Creek		
Electroshocker	mummichog banded killifish bluegill American eel golden shiner striped bass white perch largemouth bass mosquitofish	Blue Crab Callinectes sapidus
Yorktown Creek (at mouth of Creek during high tide)		
Electroshocker and Seine	Atlantic silverside striped killifish banded killifish mummichog sheepshead minnow	

	striped bass spotted seatrout	
Yorktown Creek (at Rt. 17 bridge)		
Stream bed too mucky to wade could not sample	mosquitofish	

III DISCUSSION

Fish Survey

The survey produced 19 species represented by 15 genera in 12 families (see attached list of common and scientific names). All species collected are common to the habitat and locality sampled (2) literature cited).

The occurrence of fingerling size striped bass and spotted seatrout in Yorktown Creek may indicate that the marsh is utilized as a nursery area by these and other fish species.

The miscellaneous vertebrates and invertebrates collected during the fish surveys do not represent the magnitude of "other animals" present in the streams. These specimens were collected because they were readily available at the time of the fish surveys. A survey designed to collect "other" aquatic life from the sampling sites would result in a much greater variety of specimens.

Water Quality

Water analyses of the streams (Table I) indicate very good quality for the parameters analyzed. Additionally, the occurrence of the scuds, Gammarus ssp., an amphipod, in Beaverdam, Baptist, and Great Run also attest to the high water quality of the streams. The analyses of water samples for pollutants, i.e. pesticides, heavy metals, etc., are beyond the scope of the test equipment used.

IV RECOMMENDATIONS

Protection of habitat and water quality appears to be the only meaningful recommendations. Because the streams are so small any activity within the watersheds that would degrade water quality i.e. increase siltation, pollution etc. would have a major negative impact on the aquatic life in the streams

COMMON AND SCIENTIFIC NAME OF FISHES COLLECTED FROM STREAMS ON COLONIAL NATIONAL HISTORICAL PARK, YORKTOWN, VIRGINIA

July 27-30, 1987

Family	Common Name	Scientific Name
Cyperinodontidae sheepshead	**minnow**	Cyprinodon variegatus
	mummichog	Fundulus heteroclitus
	banded killifish	Fundulus diaphanus
	striped **killifish**	Fundulus majalis
Centrarchidae	bluegill	Lepomis macrochirus
	pumpkinseed	Lepomis gibbosus
	banded sunfish	Enneacanthus obesus
	largemouth **bass**	Micropterus salmoides
Cyprinidae	**golden shiner**	Notemigonus crysoleucas
Aphredoderidae	**pirate perch**	Aphredoderus sayanus
Anguillidae	**American eel**	Anguilla rostrata
Atherinidae	Atlantic **silverside**	**Menidia menidia**
Esocidae	chain **pickerel**	**Esox niger**
Percichthyidae	striped **bass**	Morone saxatilis
	white **perch**	Morone americans
Percidae	tessalated darter	Etheostoma olmstedi
Poeciliidae	mosquitofish	Gambusia affinis
Sciaenidae	**spotted** seatrout	Cynoscion nebulosus
Umbrides	eastern **mudminnow**	**Umbra** pygmaea

LITERATURE CITED

1) Eddy, S., '**The** Freshwater Fishes." Second Edition.

2) Lee, S.D., C.R. Gilbert, C.H. Hocutt, R.e. Jenkins, D.E. McAllister and J.R. Stauffer, Jr. 1980 et seq. "Atlas of North American Freshwater Fishes." N.C. State Mus. Nat. Hist., Raleigh.

FISHERY INVENTORY AND BASELINE WATER QUALITY OF THE BACK RIVER SYSTEM, JAMESTOWN ISLAND COLONIAL NATIONAL HISTORICAL PARK, VIRGINIA

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NPS Agreement Number 4000-1-0007

Period Covered: May-October 1991

ABSTRACT

Baseline information on seasonal variation of fish species utilization and water quality parameters of the Back River system, Jamestown Island, Colonial National Historical Park, Virginia, was collected in May and October, 1991. Fish specimens were collected from 10 locations and water quality parameters were collected from 18 locations. Composition and life stage occurrence in fish species that were collected indicate that the Back River system is utilized as a nursery area for both recreationally and commercially important species. Water quality parameters collected were within acceptable ranges to promote completion of all life stages of the fish species collected. No federal or state listed threatened, rare, or endangered species were collected.

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INTRODUCTION

The Colonial National Historical Park (CNHP) entered into Interagency Agreement Number 4000-1-0007 dated May 22, 1991 with the U.S. Fish and Wildlife Service (Service), and requested therein that the Service collect baseline water quality data and compile a listing of non-migratory (resident) and migratory fish species utilizing the tidal waters (Back River System) on and around Jamestown Island.

The natural resources data base for the CNHP does not contain baseline water quality data or a current species list of fishes utilizing the tidal waters of the park. Such information is essential to enable CNHP to evaluate and monitor its natural resources program and to evaluate impacts to its aquatic resources due to pollution and off-site changes in land use practices. The Service designed a study to determine if the area was being utilized for spawning and/or nursery habitat for the fish species collected.

No previous investigations have been conducted within the study area. Historical data on fishes known to Colonial Virginians which occurred in rivers, 1607-1705, are presented in Appendix A. Fish data collected in beach seine surveys conducted by the Virginia Institute of Marine Science in July and September 1969-1973 and 1980-1989, are presented in Appendix B. Appendix C presents historical data compiled in the Biota of Virginia (BOVA) data base from fishery surveys on the James River in the vicinity of Jamestown Island and Powhatan Creek from 1942 through 1978.

STUDY AREA

The Back River system, for the purpose of this study, includes Sandy Bay, Back River, The Thorofare, Piping Point Creek, Back River Marsh Creek, Kingsmill Creek, Harman's Creek, Black Point Creek and Passamore Creek (Map 1.) Please note that the names for Piping Point Creek, Back River Marsh Creek, Harman's Creek and Black Point Creek do not appear on the Geological Survey map for CNHP. The names were given for these locations by the Service as reference points. All sampling stations within the system experienced tidal fluctuation of approximately two feet. The substrate at all sampling sites is comprised of muck, hard clay, and sand. The upper reaches of all tidal creeks contained the most muck due to less flushing action by tidal currents.

Ten fish sampling sites were established in the Back River System (Map 2). These sites were sampled by using two electrofishing boats, a 3.3 meter shrimp trawl, and minnow traps. Electrofishing methods were used during the spring (May) sampling period. Each electrofishing boat was 16 feet long, constructed of aluminum, and powered by a 30 HP outboard engine. Each boat was equipped with a Homelite Model 180RIE62, 6200 watt generator and a Smith-Root Type VI-A electrofisher unit. Each boat contained a live well and aeration equipment to keep the fish specimens alive. The sampling crew on each boat consisted of a boat operator and one or two people on the bow platform collecting fish. The fish surveys were accomplished by sampling all accessible habitat within the sample site. On Sandy Bay this involved covering all accessible waters greater than .5 meters deep. Much of the shoreline of Sandy Bay was inaccessible due to shallow water. Sampling on the tidal stream of Piping Point, Back River Marsh, Kingsmill, Harman's, Black Point, and Passamore was begun at the mouth of the creeks and electrofished to the head of the stream or until upstream progress was halted due to low water or obstructions. All habitat on the Back River from Sandy Bay to the Thorofare was accessible to electrofishing.

The electrofishing technique required establishing an electrical field between the positive electrode (anode) which extends eight feet in front of the boat, and the negative electrode (cathode) which is the hull of the aluminum boat. This field encompasses an area of approximately 20 feet in diameter around the anode and extends to a depth of about 10 feet. All fish within the electrical field may not be collected. Some fish

may be at the edge of the field and their reflex to the electrical current may force them out of the field and they escape. Other fish may be immobilized by the electricity but are swept downstream by the water current and are able to regain their mobility before they float to the surface and can be collected. In murky water the fish may not be seen by the netters and are not collected.

The electrofishing procedures required using two electrofishing boats at the same time on the same stream. On the narrow creeks i.e. Piping Point, Back River Marsh, Kingsmill, Harman's and Black Point, the total surface area of the creeks could be sampled by this procedure. One boat would sample along one side of the creek while the other boat was sampling the opposite side of the creek. Both boats would start at the mouth of the creek and sample upstream to the end of the sampling area. On the Back River and Passamore Creek the same procedure was used but because both areas were much more extensive in size it was not possible to cover 100% of the surface area. Instead, sampling was concentrated along the creek banks where logs, brush, deep holes and undercut banks provided the best fish attracting habitat. Electrofishing in Sandy Bay was concentrated on areas deeper than .5 meters.

In most instances when electrofishing, the boats were in motion at all times traveling at a slow idle. However, when sampling around logs, brush, deep holes, undercut banks and other fish attracting habitat it was necessary to remain stationary for short duration's to allow the fish to float to the surface. As the fish floated to the surface they were collected with dip nets by the netters standing on the bow of the boats. The fish were then placed in the live well on the boat and held there until they were identified, measured, weighed, and then released. The length of time the fish were held in the live well before they were released depended on how many fish were being collected over time. Generally the operation would cease after a half hour of operation for recordation of data. The sampling would then resume until the site was thoroughly sampled.

The electrofishing boats used were not effective in high salinity water (greater than 1 part per thousand (ppt). During the May sampling period water quality was favorable for electrofishing. Fresh water flow throughout the Back River system in May kept the salinity level below 1 ppt. Because of reduced fresh water flow during the October sampling, the salinity level in the Back River system rose to levels too high to use the electrofishing equipment.

Trawl surveys were used in place of electrofishing gear during the October sampling because high salinity waters rendered the electrofishing gear ineffective in collecting fish samples. The trawl is an elongated bag net designed to be pulled behind a boat. As fish enter the net they are forced into the closed end of the net (cod end) which is restricted in size. At the end of a sampling run (net tow) the trawl is pulled into the boat, the cod end is opened and the fish are placed in the live well. The trawl used for the surveys is referred to as a "bottom trawl" meaning the trawl is designed to slide along the bottom and capture bottom dwelling fish. The particular trawl used was a 3.3 meter (size of the mouth opening of the net) shrimp trawl constructed from nylon netting material with a 33 millimeter stretch mesh size. Inside the bag of the net was a bag liner made form 3 millimeter stretch mesh size. The liner was used to prevent small fish from passing through the net. On each side of the mouth opening of the trawl are positioned trawl boards (61 X 31 cm). When the trawl is pulled the trawl boards will plane in opposite directions to keep the mouth of the trawl open. The trawl was attached to the boat with a tow line and was approximately 30 feet behind the boat. Setting the trawl in preparation for a net tow required two people in the boat--one to put the trawl overboard while the other ran the boat to keep the net out of the prop on the outboard motor. Once the trawl was set the boat maintained a speed of 2-3 miles per hour while pulling the net. If it was possible to sample the entire creek without stopping, then the creek could be sampled on one net tow. Often the net tow had to be stopped because the net snagged on bottom debris or sharp bends in the creek channel prevented pulling the trawl around the bends. When the tow stopped the trawl was pulled into the boat and the fish were put into the live well. The tow would start again once the obstructions were cleared.

The trawl would effectively sample a zone along the bottom approximately 8 feet wide and extending from the bottom to approximately 3 feet above the bottom.

Minnow traps were used to sample areas that could not be sampled by electrofishing or by the trawl. On October 23 plastic minnow traps, (43 X 22 cm) with 3 cm throat opening, were fished over night in Harman's Creek and Black Point Creek. Two traps at each location were tied to the bridge pilings where the loop road crossed the creeks. The traps were baited with dry dog food, which dissolved and produced a chum line to attract the fish to the traps.

Water sampling sites were established at 18 locations in the Back River system (Map 3). These sites were located generally at the mouth of the creek and at a point farther upstream to detect any change in water quality. The water quality parameters for temperature, dissolved oxygen, salinity, conductivity, pH, and oxidation-reduction potential (redox) were measured from the surface to the bottom at one-half meter intervals with a Hydrolab@ Surveyor II water quality meter. Total Dissolved Solids (TDS) were measured at the surface with a Hach@ Model 44600 Conductivity/TDS meter. Water transparency was measured with a 20 cm diameter secchi disk with alternate black and white quadrants. All water quality values for each creek were collected on the same day that the fish surveys were conducted.

All sites were sampled by electrofishing during the weeks of May 7-10 and May 21-24 and by trawl the week of October 21-25. A total of 2,276 fish were collected and measured in millimeters (mm) to total length (TL)(Table 1). Data is provided on total number of fish collected at each site for each sampling period and also the total number for each species (Table 2). The fishes collected represented 36 species in 18 families (Table 3). These data illustrate that the May survey using electrofishing methods were more successful than the October survey using the trawl in collecting fishes due to the ability of the electrofisher to sample a greater diversity of habitat. Table 4 illustrates the probable life stage uses of the fishes in the Back River system. This information is derived from the survey data based on TL measurement of fish captured and the results of life history studies conducted by fisheries researchers over many years (Johnson 1978; Jones et. al. 1978; Hardy 1978a; Hardy 1978b; Lee et. al. 1980; Martin and Drewry 1978).

Results from the water quality monitoring are presented in Table 5. The change in water quality values observed between the May and October sampling period for salinity, conductivity and total dissolved solids are significant. These three water quality parameters are co-dependent due to the dissolved salts associated with the estuarine environment of the study area. A change in the value for one parameter will change the value for the others. During the May sampling period the Back River system had mostly fresh water flowing through it due to spring precipitation and the fresh water flow from the James River. These conditions resulted in low values for salinity, conductivity, and total dissolved solids, which made it feasible to use the electrofishing gear to collect fish samples. During the October sampling period the system had become a brackish environment due to reduced flow of fresh water. The brackish conditions resulted in high values for salinity, conductivity and total dissolved solids which made the electrofishing gear ineffective for collecting fish samples and therefore required the use of the trawl. Although seasonal changes in water quality were quite pronounced, all parameters measured were within acceptable ranges for all fish species present.

Table 1: Fish species distribution by station, month, number captured, and size range (mm in parenthesis), Back River System, Jamestown Island, CNHP, VA. (May and October, 1991)

Species	Sandy Bay		Back River (upper)		Piping Point		Back River (lower)		Back River Marsh	
	JIBRSB		JIBRUS		JIBRPP		JIBRLS		JIBRBM	
	May	October	May	October	May	October	May	October	May	October
Anchovy, Bay	9 (48-58)	7 (45-57)	17 (42-73)	127 (29-74)	4 (48-67)	- -	3 (46-57)	82 (29-88)	2 (55-63)	- -
Bass, Largemouth	18 (152-374)	- -	32 (145-485)	- -	13 (211-410)	- -	3 (237-285)	- -	7 (297-407)	- -
Bass, Striped	5 (83-139)	2 (85-104)	8 (95-195)	- -	- -	- -	1 (120)	- -	- -	- -
Bluegill	4 (55-125)	- -	26 (50-195)	- -	8 (75-175)	- -	1 (149)	- -	3 (67-157)	- -
Bowfin	- -		- -	- -	8 (420-615)	- -	- -	- -	2 (585-660)	- -
Bullhead, Brown	3 (222)		6 (190-272)	- -	4 (184-220)	- -	7 (140-205)	- -	1 (205)	- -
Bullhead, Yellow	1 (267-267)		1 (197)	- -	- -	- -	- -	- -	- -	- -
Carp	- -		13 (480-540)	- -	3 (35-420	- -	1 (507)	- -	3 (210-548)	1 (547)

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Catfish, Blue *	- -		- -	- -	- -	- -	- -	-	- -	- -
Catfish, Channel	21 (180-610)		68 (142-685)	- -	2 (410-482)	- -	3 (337-472)	- -	2 (425-450)	- -
Catfish, White	- -		- -	- -	2 (235-240)	- -	- -	- -	1 (257)	- -
Chubsucker, Creek	- -		- -	- -	- -	1 (150)	- -	- -	- -	- -
Croaker, Atlantic	5 (76-88)		1 (44)	- -	2 (95-109)	- -	16 (46-85)	2 (21-40)	1 (42)	- -
Darter, Tessellated	1 (74)		- -	- -	- -	- -	- -	- -	- -	- -
Eel, American	**	- -	**	- -	**	- -	**	- -	**	- -
Flounder, Summer	- -	- -	1 (70)	- -	- -	2 (47-60)	- -	- -	- -	- -
Goby, Naked	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Hogchoker	9 (34-105)	36 (25-80)	4 (40-77)	1 (40)	10 (49-80)	5 (45-91)	- -	- -	- -	4 (32-90)
Killifish, Banded	18 (42-70)	- -	27 (40-82)	- -	16 (42-82)	- -	- -	- -	- -	- -
Menhaden, Atlantic	24 (35-157)	- -	6 (45-132)	- -	- -	- -	- -	- -	6 (37-140	- -

									)	
*Mullet, Striped	1 (250)	- -	5 (92-312)	- -	1 (252)	- -	- -	- -	- -	- -
Mullet, White	5 (243-286)	- -	6 (72-340)	- -	- -	- -	1 (254)	- -	3 (257-28 7)	- -
Mummichog	4 (52-92)	- -	62 (42-92)	- -	26 (33-82)	- -	- -	- -	18 (40-67)	- -
Perch, White	51 (65-178)	4 (87-214)	72 (43-234)	- -	58 (85-245)	6 (66-82)	12 (87-193)	- -	38 (42-247)	- -
Perch, Yellow	- -	- -	4 (236-28 8)	- -	3 (222-29 1)	- -	2 (33-270)	- -	3 (245-26 5)	- -
Pipefish	- -	1 (106)	- -	- -	- -	- -	- -	- -	- -	- -
Shad, Gizzard	57 (95-155)	- -	17 (120-30 5)	- -	56 (132-33 6)	- -	- -	- -	27 (140-36 9)	- -
Shad, Threadfin	2 (100-104)	- -	5 (90-132)	- -	- -	- -	- -	- -	- -	- -
Shiner, Golden	- -	- -	16 (82-149)	- -	10 (78-147)	- -	2 (263-29 2)	- -	2 (140-17 2)	- -

Shiner, Spottail	4 (75-89)	- -	- -	- -	- -	- -	- -	- -	- -	- -
Silverside, Tidewater	8 (57-105)	- -	31 (50-71)	- -	1 (60)	- -	1 (59)	- -	6 (55-78)	- -
Spot	- -	19 (97-121)	2 (52-133)	2 (120-120)	47 (43-105)	5 (102-122)	21 (20-52)	- -	- -	7 (95-127)
Sunfish, Pumpkinseed	31 (80-147)	- -	45 (67-149)	- -	35 (57-165)	- -	9 (83-168)	- -	12 (110-147)	- -
Sunfish, Redbreasted	3 (125-182)	-	-	-	-	-	-	-	-	-
Sunfish, Redear	-	-	4 (110-151)	-	-	-	-	-	-	-
Warmouth	- -	- -	1 (72)	- -	- -	- -	- -	- -	2 (150-165)	- -

Table 1: Fish species distribution by station, month, number captured, and size range (mm in parenthesis), Back River System, Jamestown Island, CNHP, VA. (May and October, 1991).

Species	Kingsmill		Harman's		Black Point		Passamore (upper)		Passamore (lower)	
	JIBRKM		JIBRHC		JIBRBP		JIPCLH		JIPCUH	
	May	October	May	October	May	October	May	October	May	October
Anchovy, Bay	- -	- -	- -	- -	NS -	- -	3 (57-70)	25 (25-64)	- -	3 (56-75)
Bass, Largemouth	5 (280-326)	- -	- -	- -	NS -	- -	- -	- -	1 (300)	- -
Bass, Striped	2 (125-147)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Bluegill	3 (51-160)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Bowfin	1 (407)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Bullhead, Brown	2 (220-245)	- -	- -	- -	NS -	- -	2 (147-185)	- -	- -	- -
Bullhead, Yellow	- -	- -	- -	- -	NS -	- -	- -	- -	- -	1 (618)
Carp	6 (475-517)	3 (480-504)	4 (370-535)	- -	NS -	- -	2 (475-516)	- -	3 (450-592)	

Catfish, Blue *	- -	- -	- -	- -	NS -	- -	- -	- -	- -	
Catfish, Channel	6 (303-485)	- -	- -	- -	NS -	- -	9 (420-740)	- -	3 (432-507)	- -
Catfish, White	- -	- -	- -	- -	NS -	- -	5 (105-325)	- -	2 (235-272)	
Chubsucker, Creek	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Croaker, Atlantic	2 (95-109)	- -	- -	- -	NS -	- -	5 (83-103)	7 (25-64)	- -	13 (22-87)
Darter, Tessellated	- -	- -	- -	- -	NS -	- -	- -	- -	-	-
Eel, American	**	- -	**	- -	NS -	- -	**	- -	**	- -
Flounder, Summer	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Goby, Naked	- -	- -	- -	1 *** (43)	NS -	4 *** (35-52)	- -	- -	- -	- -
Hogchoker	- -	10 (38-96)	- -	- -	NS -	- -	10 (40-67)	4 (36-72)	- -	29 (30-85)
Killifish, Banded	9	-	-	-	NS	1	9	-	16	-

	(41-73)	-	-	-	-	(72)	(43-90)	-	(41-95)	-
Menhaden	1 (172)	- -	1 (165)	- -	NS -	- -	1 (138)	- -	- -	- -
Mullet, Striped	6 (202-285)	- -	4 (232-252)	- -	NS -	- -	6 (250-295)	- -	5 (266-405)	- -
Mullet, White	2 (211-265)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Hogchoker	7 (60-87)	- -	- -	12 (56-92)	NS -	4 (55-77)	26 (36-105)	- -	6 (37-87)	- -
Killifish, Banded	24 (74-172)	13 (45-160)	13 (85-231)	- -	NS -	- -	45 (31-210)	3 (120-132)	28 (107-235)	20 (56-163)
Menhaden, Atlantic	1 (255)	- -	- -	- -	NS -	- -	1 (300)	- -	- -	- -
Mullet, Striped	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Shad, Gizzard	2 (289-365)	- -	10 (135-282)	- -	NS -	- -	8 (142-308)	- -	10 (30-320)	- -

Shad, Threadfin	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Shiner, Golden	4 (90-172)	- -	1 (124)	- -	NS -	- -	- -	- -	- -	- -
Shiner, Spottail	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Silverside, Tidewater	2 (57-67)	- -	- -	- -	NS -	- -	- -	- -	1 (68)	- -
Spot	2 (27-41)	17 (104-138)	1 (73)	- -	NS -	- -	69 (32-110)	4 (87-125)	- -	20 (96-141)
Sunfish, Pumpkinseed	12 (72-140)	- -	3 (105-122)	- -	NS -	- -	3 (112-115)	- -	1 (135)	- -
Sunfish, Redbreasted	1 (110)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Sunfish, Redear	2 (124-145)	- -	- -	- -	NS -	- -	- -	- -	- -	- -
Warmouth	- -	- -	- -	- -	NS -	- -	- -	- -	- -	- -

* = One juvenile observed in possession of a fisherman: none collected
** = American Eels, 50mm and larger were prevalent at each station; none collected
*** = Collected in minnow trap
NS = Not Sampled: inadvertently omitted

Table 2: Total number of fish collected per sampling period and total number per species (May and October, 1991

	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]	
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[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]	
[illegible]	[illegible]		[illegible]												[illegible]	
[illegible]			[illegible]		[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
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[illegible]														[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]		[illegible]			[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]						[illegible]				[illegible]	[illegible]
[illegible]	[illegible]		[illegible]						[illegible]		[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]						[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]				[illegible]		[illegible]		[illegible]				[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]				[illegible]		[illegible]			[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]			[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]	
[illegible]		[illegible]													[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]				[illegible]		[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]												[illegible]	
[illegible]			[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]														[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]										[illegible]				[illegible]	
[illegible]			[illegible]						[illegible]		[illegible]				[illegible]	
[illegible]			[illegible]												[illegible]	
Total # of fish at each site	284	112	480	130	309	19	83	84	139	12	102	53	37	13	NS	9

*   = One juvenile observed in possession of a fisherman: none collected
** = American Eels, 50mm and larger were prevalent at each station; none collected
*** = Collected in minnow trap
NS = Not Sampled: inadvertently omitted

Species	JIPCLH		JIPCUH		Total # of fish for each specie
	May	Oct	May	Oct	
[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]			[illegible]		[illegible]
[illegible]					[illegible]
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[illegible]	[illegible]				[illegible]
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[illegible]					[illegible]
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[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]		[illegible]		[illegible]
[illegible]	[illegible]				[illegible]
[illegible]	[illegible]		[illegible]		[illegible]
[illegible]					[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]				[illegible]
[illegible]					[illegible]
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[illegible]			[illegible]		[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]		[illegible]		[illegible]
[illegible]					[illegible]
[illegible]					[illegible]
[illegible]					[illegible]
Total # of fish at each site	204	43	76	87	

Table 3: Fish species collected from the Back River system, Jamestown Island, Colonial National Historical Park, Virginia (May and October, 1991

Family:	Genus / Specie:	Common Name:
Anguillidae	Anguilla rostrata	American Eel
Atherinidae	Menidia beryllina	Tidewater Silverside
Bothidae	Paralichthys dentatus	Summer Flounder
Catostomidae	Erimyzon oblongus	Creek Chubsucker
Centrarchidae	Lepomis auritus	Redbreasted Sunfish
	Lepomis gibbosus	Pumpkinseed Sunfish
	Lepomis gulosus	Warmouth
	Lepomis macrochirus	Bluegill
	Lepomis microlophus	Redear Sunfish
	Micropterus salmoides	Largemouth Bass
Clupeidae	Brevoortia tyrannus	Atlantic Menhaden
	Dorosoma cepedianum	Gizzard Shad
	Dorosoma petenense	Threadfin Shad
Cyprinidae	Cyprinus carpio	Carp
	Notemigonus crysoleucas	Golden Shiner
	Notropis hudsonius	Spottail Shiner
Cyprinodontidae	Fundulus diaphanus	Banded Killifish
	Fundulus heteroclitus	Mummichog
Engraulidae	Anchoa mitchilli	Bay Anchovy
Gobiidae	Gobiosoma bosci	Naked Goby
Ictaluridae	Ameirus natalis	Yellow Bullhead
	Ameirus nebulosus	Brown Bullhead
	Ictalurus catus	White Catfish
	Ictalurus furcatus	Blue Catfish
	Ictalurus punctatus	Channel Catfish
Mugilidae	Mugil cephalus	Striped Mullet
	Mugil curema	White Mullet
Percichthyidae	Morone americana	White Perch
	Morone saxatilis	Striped Bass
Percidae	Etheostoma olmstedi	Tessellated Darter
	Perca flavescens	Yellow Perch
Sciaenidae	Leiostomus xanthurus	Spot
	Micropogonias undulatus	Atlantic Croaker
Soleidae	Trinectes maculatus	Hogchoker
Syngnathidae	Syngnathus fuscus	Pipefish

Table 4: Life stage uses of non-migratory and migratory fish of the Back River system, Jamestown Island, Colonial National Historical Park, Virginia.

Species			Life Stage Uses		
	Non-Migratory	Migratory	Spawning	Nursery	Resident
Anchovy, Bay *Anchoa mitchilli*	X		X	X	X
Bass, Largemouth *Micropterus salmoides*	X		? (5)	X	X
Bass, Striped *Morone saxatilis*		X (1)		X	
Bluegill *Lepomis macrochirus*	X		? (5)	X	X
Bowfin *Amia calva*	X		? (5)	X	X
Bullhead, Brown *Ameirus nebulosus*	X		? (5)	X	X
Bullhead, Yellow *Ameirus natalis*	X		? (5)	X	X
Carp *Cyprinus carpio*	X		? (5)	X	X
Catfish, Blue *Ictalurus furcatus*	X		? (5)	X	X
Catfish, Channel *Ictalurus punctatus*	X		? (5)	X	X
Catfish, White *Ictalurus catus*	X		? (5)	X	X
Chubsucker, Creek *Erimyzon oblongus*	X		? (5)	X	X
Croaker, Atlantic *Micropogonias undulatus*	X	X (2)		X	
Darter, Tessellated *Etheostoma olmstedi*	X		? (5)	X	X
Eel, American *Anguilla rostrata*		X (3)		X	X
Flounder, Summer *Paralichthys dentatus*		X (2)		X	
Goby, Naked *Gobiosoma bosci*	X		X	X	X
Hogchoker *Trinectes maculatus*	X		X	X	X

Table 4: Life stage uses of non-migratory and migratory fish of the Back River system, Jamestown Island, Colonial National Historical Park, Virginia.

Species			Life Stage Uses		
	Non-Migratory	Migratory	Spawning	Nursery	Resident
Killifish, Banded *Fundulus diaphanus*	X		X	X	X
Menhaden, Atlantic *Brevoortia tyrannus*		X (2)		X	
Mullet, Striped *Mugil cephalus*		X (2)		X	
Mullet, White *Mugil curema*		X (2)		X	
Mummichog *Fundulus heteroclitus*	X		X	X	X
Perch, White *Morone americana*		X (4)		X	X
Perch, Yellow Perca flavescens	X		X (5)	X	X
Pipefish *Syngnathus fuscus*	X		X	X	X
Shad, Gizzard *Dorosoma cepedianum*	X		? (5)(6)	X	X
Shad, Threadfin *Dorosoma petenensis*	X		? (5)(6)	X	X
Shiner, Golden *Notemigonus crysoleucas*	X		? (5)	X	X
Shiner, Spottail *Notropis hudsonius*	X		? (5)	X	X
Silverside, Tidewater *Menidia beryllina*	X		X	X	X
Sunfish, Pumpkinseed *Lepomis gibbosus*	X		? (5)	X	X
Sunfish, Redbreasted *Lepomis auritus*	X		? (5)	X	X
Sunfish, Redear *Lepomis microlophus*	X		? (5)	X	X
Warmouth *Lepomis gulosus*	X		? (5)	X	X

(1) Anadromous to semi-anadromous specie

(2) Spawn in open marine areas, eggs and larvae move by currents back into estuarine areas
(3) Adults migrate from freshwater to spawn and die in open marine area (Sargasso Sea). Elvers (young eels)
migrate back into freshwater to mature into adults (only Catadromous specie in the Chesapeake Bay).
(4) Adults spawn in open deeper areas in the bay and lower tidal areas. The young move up and into estuarine
shallow areas to mature. At maturity they move back into the bay and lower tidal areas (deeper water).
(5) May inhabit brackish waters, but they require low to no salinity for reproduction. This requirement
dictates if any spawning may occur in the waters of Jamestown Island, CNHP, Va.
Current data indicates that the salinity levels are low enough to support spawning activities
as long as the system receives normal rainfall to flush the backwater areas.
(6) Require some sort of substrate (i.e., submerged and inundated vegetation, roots, brush, gravel, rocks, boulders,
or sometimes sand) for spawning. The Back River most likely contains suitable habitat for spawning,
but it is very doubtful that the remaining creeks have suitable spawning habitat.

Table 5: Water quality data from the Back River system, Jamestown Island, Colonial National Historical Park (May and October 1991

Area	Station	Date	Depth (m)	Temp (C)	pH	D.O. (ppm)	Cond (mmhos/cm)	ORP (V)	Sal (ppt)	TDS (ppm)	Air Temp		Tide Stage*	Secchi Disk (m)
											(C)	Time		
NPS	JIBM01	05/23/91	Surface	25.00	6.84	11.40	0.356	0.126	0.0	0.49	26.40	1115	5	0.27
Back River Marsh Creek (upper)		05/23/91	0.5	24.50	6.95	9.10	1.061	0.144	0.0					
		05/23/91	1.0	24.40	6.83	8.40	1.052	0.146	0.0					
		10/23/91	Surface	16.61	7.49	9.15	9.740	0.105	5.1	4.92	17.88	1025	2	0.55
		10/23/91	0.5	16.55	7.47	9.13	9.770	0.106	5.2					
		10/23/91	1.0	16.56	7.45	9.17	9.810	0.107	5.2					
		10/23/91	1.5	16.55	7.44	9.13	9.850	0.108	5.2					
		10/23/91	1.9	16.55	7.43	9.13	9.860	0.109	5.2					
NPS	JIBM02	05/23/91	Surface	25.56	7.00	9.10	0.202	0.103	0.0	0.38	-	1140	5	0.46
Back River Marsh Creek (lower)		05/23/91	0.5	24.62	7.14	8.01	0.585	0.110	0.0					
		05/23/91	1.0	24.10	7.13	7.47	0.592	0.11	0.0					

								2						
		10/22/91	Surface	17.35	7.48	10.10	8.980	0.100	4.7	4.42	16.42	1430	5	0.55
		10/22/91	0.5	17.26	7.43	10.07	9.020	0.101	4.7					
		10/22/91	1.0	17.25	7.42	10.00	9.040	0.103	4.7					
		10/22/91	1.5	17.09	7.42	9.90	9.160	0.105	4.8					
NPS	JIBPO1	10/23/91	Surface	18.17	7.50	9.16	11.720	0.117	6.4	5.70	19.20	1400	5	0.31
Black Point Creek		10/23/91	0.5	18.14	7.49	9.23	11.720	0.117	6.4					
		10/23/91	1.0	18.07	7.48	9.26	11.700	0.116	6.4					
		10/23/91	1.3	18.06	7.47	9.24	11.730	0.116	6.4					
NPS	JIBR01	05/09/91	Surface	21.94	8.34	9.18	0.248	0.139	0.0	-	19.55	1230	6	0.58
Back River (lower)		05/09/91	0.5	21.98	8.25	9.15	0.246	0.140	0.0					
		05/09/91	1.0	21.98	8.24	9.18	0.244	0.140	0.0					
		05/10/91	1.5	21.97	8.22	9.16	0.243	0.140	0.0					
		10/22/92	Surface	16.64	7.58	9.65	10.390	0.104	5.5	5.16	16.42	1400	5	0.58
		10/22/92	0.5	16.55	7.62	9.71	10.420	0.104	5.5					
		10/22/92	1.0	16.46	7.62	9.62	10.530	0.106	5.6					
		10/22/92	1.5	16.46	7.61	9.50	10.66	0.10	5.7					

							0	7						
		10/22/92	2.0	16.28	7.60	9.46	10.730	0.109	5.8					
		10/22/92	2.5	16.30	7.59	9.40	10.810	0.112	5.8					
		10/22/92	3.0	16.24	7.58	9.40	10.830	0.112	5.8					
		10/22/92	3.2	16.25	7.58	9.40	10.820	0.112	5.8					
NPS	JIBR02	05/09/91	Surface	21.73	8.66	9.90	0.196	0.100	0.0	-	18.91	1400	7	0.58
Back River (upper)		05/09/91	0.5	21.79	8.62	9.85	0.195	0.101	0.0					
		05/09/91	1.0	21.78	8.60	9.91	0.195	0.102	0.0					
		05/09/91	1.3	21.78	8.59	9.90	0.196	0.102	0.0					
		10/22/91	Surface	16.68	7.60	9.77	10.290	0.122	5.5	5.15	15.57	1245	5	0.58
		10/22/91	0.5	16.58	7.65	9.55	10.360	0.112	5.5					
		10/22/91	1.0	15.88	7.61	9.43	10.670	0.115	5.7					
		10/22/91	1.5	15.83	7.60	9.35	10.850	0.116	5.8					
		10/22/91	2.0	15.87	7.57	9.22	10.920	0.118	5.9					
		10/22/91	2.5	15.85	7.55	9.09	11.060	0.120	5.9					
		10/22/91	3.0	15.83	7.53	9.03	11.010	0.121	6.0					
		10/22/91	3.5	15.84	7.51	8.90	11.230	0.123	6.0					
		10/22/91	3.7	15.83	7.51	8.91	11.25	0.12	6.1					

							0	3						
NPS	JIHC01	05/24/91	Surface	23.10	6.64	6.64	0.590	0.146	0.0	0.81	22.40	1000	4	0.55
Harman's Creek		05/24/91	0.6	24.60	6.64	6.04	1.700	0.153	0.4					
		10/23/91	Surface	19.08	7.52	9.29	3.650	0.113	1.5	5.35	-	1245	4	0.55
		10/23/91	0.4	17.31	7.64	9.97	11.160	0.108	6.0					
NPS	JIKM01	05/10/91	Surface	20.09	7.34	4.12	1.215	0.144	0.1	-	20.90	1111	5	0.58
Kingsmill (upper)		05/10/91	0.5	20.08	7.20	3.93	1.222	0.141	0.1					
		05/10/91	1.0	20.06	7.17	3.71	1.229	0.142	0.1					
		10/23/91	Surface	16.15	7.31	8.29	9.200	0.129	4.9	4.73	18.00	1130	5	0.58
		10/23/91	0.5	16.23	7.15	8.40	9.470	0.129	4.9					
		10/23/91	0.7	16.20	7.14	8.44	9.530	0.128	5.0					
NPS	JIKM02	05/10/91	Surface	21.41	7.65	7.27	0.699	0.132	0.0	-	-	-	6	-
Kingsmill (lower)		05/10/91	0.5	21.28	7.57	7.26	0.698	0.133	0.0					
		05/10/91	1.0	21.31	7.52	7.21	0.700	0.133	0.0					
		10/23/91	Surface	17.43	7.62	9.52	11.220	0.109	6.1	5.48	19.80	1200	3	0.58

		10/23/91	0.5	17.29	7.66	9.49	11.320	0.110	6.1					
		10/23/91	1.0	17.29	7.66	9.47	11.350	0.111	6.1					
		10/23/91	1.5	17.29	7.66	9.47	11.350	0.112	6.1					
		10/23/91	2.0	17.26	7.65	9.44	11.390	0.113	6.2					
		10/23/91	2.4	17.26	7.64	9.39	11.410	0.115	6.2					
NPS	JIPC01	05/21/91	Surface	20.80	6.47	5.00	0.777	0.143	0.0	-	21.50	1100	6	-
Passamore (lower)		05/21/91	0.5	20.20	6.57	5.15	2.330	0.145	0.7					
		10/24/91	Surface	17.80	7.62	9.02	11.990	0.133	6.6	5.93	17.32	1115	3	0.71
		10/24/91	0.50	17.76	7.61	9.00	12.080	0.133	6.6					
		10/24/91	1.00	17.75	7.61	9.00	12.100	0.134	6.6					
		10/24/91	1.50	17.77	7.61	8.99	12.140	0.134	6.6					
		10/24/91	2.00	17.81	7.60	8.98	12.470	0.135	6.7					
		10/24/91	2.50	17.87	7.59	8.87	12.460	0.138	6.8					
		10/24/91	3.00	17.90	7.61	8.85	12.600	0.120	6.8					
		10/24/91	3.30	17.88	7.61	8.84	12.650	0.122	7.0					
NPS	JIPC02	05/21/91	Surface	20.90	6.39	6.00	0.805	0.162	0.0	-	-	1200	7	0.46
Passamore		05/21/91	0.5	20.79	6.69	5.58	2.360	0.164	0.8					

		05/21/91	1.0	20.91	6.58	5.69	2.430	0.167	0.8					
		05/21/91	1.5	20.84	6.55	5.68	2.430	0.168	0.8					
		05/21/91	1.8	20.89	6.53	5.64	2.430	0.168	0.8					
		10/24/91	Surface	17.96	7.65	9.00	12.270	0.125	6.7	6.11	18.75	1200	3	0.62
		10/24/91	0.5	17.92	7.64	8.98	12.300	0.126	6.7					
		10/24/91	1.0	17.93	7.64	8.98	12.310	0.126	6.7					
		10/24/91	1.5	17.92	7.63	8.95	12.330	0.126	6.7					
		10/24/91	2.0	17.93	7.63	9.01	12.350	0.127	6.8					
NPS	JIPC03	05/24/91	Surface	24.20	7.10	7.34	1.670	0.118	0.4	-	31.10	1200	5	0.30
Passamore		05/24/91	0.5	24.10	7.14	7.34	1.670	0.119	0.4					
		05/24/91	1.0	24.00	7.14	7.29	1.660	0.122	0.4					
		05/24/91	1.5	24.00	7.14	7.27	1.660	0.124	0.4					
		05/24/91	2.0	24.00	7.15	7.27	1.660	0.124	0.4					
		05/24/91	2.5	24.00	7.16	7.32	1.670	0.127	0.4					
		05/24/91	3.0	24.00	7.16	7.32	1.660	0.129	0.4					

		05/24/91	3.5	24.00	7.16	7.34	1.670	0.131	0.4					
		05/24/91	3.7	24.00	7.16	7.34	1.660	0.133	0.4					
		10/24/91	Surface	17.97	7.63	8.96	12.240	0.115	6.7	6.05	18.70	1215	3	0.58
		10/24/91	0.5	17.95	7.64	8.98	12.270	0.115	6.7					
		10/24/91	1.0	17.94	7.63	8.98	12.270	0.117	6.7					
		10/24/91	1.5	17.94	7.63	8.97	12.280	0.117	6.7					
		10/24/91	2.0	17.94	7.63	8.97	12.290	0.118	6.7					
		10/24/91	2.5	17.95	7.63	8.97	12.310	0.118	6.7					
		10/24/91	3.0	17.94	7.63	8.97	12.310	0.119	6.7					
		10/24/91	3.5	17.94	7.63	8.94	12.350	0.119	6.8					
		10/24/91	3.8	17.94	7.63	8.94	12.340	0.120	6.8					
NPS	JIPC04	05/23/91	Surface	26.80	6.80	8.17	2.290	0.139	0.7	1.12	-	1400	3	0.46
Passamore		05/23/91	0.5	26.50	6.90	8.03	2.300	0.144	0.7					
		05/23/91	1.0	25.90	6.91	7.66	2.300	0.148	0.7					
		05/23/91	1.5	25.70	6.87	7.11	2.300	0.150	0.7					
		05/23/91	2.0	25.50	6.83	7.08	2.300	1.520	0.7					
		05/23/91	2.3	25.50	6.80	6.95	2.300	0.150	0.7					
		10/24/91	Surface	18.07	7.57	8.98	11.99	0.10	6.5	6.03	21.6	123	3	0.58

			e				0	0			0	0		
		10/24/91	0.5	18.06	7.63	8.99	11.990	0.100	6.6					
		10/24/91	1.0	18.06	7.63	8.99	12.070	0.101	6.6					
		10/24/91	1.5	17.98	7.62	8.99	12.060	0.102	6.6					
		10/24/91	1.7	17.97	7.62	9.00	12.050	0.103	6.6					
NPS	JIPC05	05/23/91	Surface	26.40	6.87	7.97	2.130	0.127	0.0	1.06	-	1420	3	0.46
Passamore		05/23/91	0.5	26.00	6.95	7.70	2.210	0.136	0.7					
		05/23/91	1.0	25.40	6.91	7.16	2.210	0.141	0.7					
		05/23/91	1.5	24.90	6.89	7.05	2.210	0.145	0.7					
		05/23/91	2.0	24.70	6.86	6.81	2.200	0.148	0.7					
		05/23/91	2.5	24.70	6.83	6.73	2.200	0.149	0.7					
		05/23/91	2.9	24.70	6.83	6.70	2.210	0.151	0.7					
		10/24/91	Surface	18.12	7.65	8.92	11.970	0.126	6.5	8.87	19.75	1330	5	0.58
		10/24/91	0.5	18.11	7.65	8.99	11.950	0.125	6.5					
		10/24/91	1.0	18.11	7.64	9.00	11.950	0.125	6.5					
		10/24/91	1.5	18.14	7.64	9.00	11.970	0.125	6.5					
		10/24/91	2.0	18.11	7.62	8.96	11.990	0.125	6.5					
NPS	J	10/24/91	Surfac	18.22	7.58	8.69	11.98	0.11	6.5	5.95	21.1	131	3	0.58

	IPCO6		e				0	6			3	5		
Passamore		10/24/91	0.5	18.13	7.56	8.72	12.010	0.117	6.5					
		10/24/91	1.0	18.10	7.54	8.70	12.030	0.118	6.6					
		10/24/91	1.3	18.07	7.52	8.67	12.030	0.120	6.6					
NPS	JIPP01	05/22/91	Surface	24.40	7.95	16.15	0.949	0.083	0.0	0.44	24.87	1232	7	0.20
Piping Point (upper)		05/22/91	0.5	12.10	7.32	11.80	0.956	0.117	0.0					
		05/22/91	1.0	22.23	6.99	7.74	0.954	0.147	0.0					
		05/22/91	1.2	21.92	6.76	7.33	0.953	0.150	0.0					
		10/23/91	Surface	16.47	7.52	9.07	8.640	0.098	4.5	4.35	15.20	949	2	0.64
		10/23/91	0.5	16.55	7.50	9.02	8.640	0.099	4.5					
		10/23/91	1.0	16.55	7.49	9.02	8.640	0.101	4.5					
		10/23/91	1.4	16.59	7.48	8.99	8.650	0.102	4.5					
NPS	JIPP02	05/22/91	Surface	23.35	7.50	13.85	0.911	0.123	0.0	-	-	1400	7	-
Piping Point (lower)		05/22/91	0.5	24.75	7.51	11.31	0.854	0.141	0.0					

		05/22/91	1.0	22.56	7.10	6.99	0.832	0.155	0.0					
		10/22/91	Surface	16.35	7.56	9.64	9.390	0.118	4.9	4.69	16.90	1315	5	0.55
		10/22/91	0.5	16.40	7.54	9.70	9.410	0.119	4.9					
		10/22/91	1.0	16.37	7.53	9.69	9.400	0.119	4.9					
		10/22/91	1.5	16.41	7.52	9.67	9.380	0.120	4.9					
		10/22/91	2.0	16.47	7.51	9.64	9.410	0.122	4.9					
		10/22/91	2.3	16.52	7.50	9.69	9.340	0.124	4.9					
NPS	JISB01	05/07/91	Surface	22.26	9.08	11.20	0.208	0.090	0.0	-	18.98	1228	8	0.55
Sandy Bay (lower)		05/07/91	0.5	22.32	9.03	11.25	0.206	0.100	0.0					
		05/07/91	0.8	22.35	9.03	11.34	0.208	0.106	0.0					
		10/21/91	Surface	16.61	7.81	9.69	8.900	0.112	4.6	4.40	18.00	1340	5	0.64
		10/21/91	0.5	16.54	7.82	9.54	8.950	0.112	4.7					
		10/21/91	0.8	16.53	7.81	9.55	8.960	0.113	4.7					
NPS	JISB02	05/07/91	Surface	24.33	8.32	10.35	0.289	0.103	0.0	-	-	1350	1	0.34
Sandy Bay (upper)		05/07/91	0.5	23.77	8.33	10.43	0.287	0.108	0.0					
		05/07/91	0.8	23.52	8.33	10.30	0.285	0.11	0.0					

						4						
10/21/92	Surface	16.12	7.63	9.85	7.930	0.123	4.0	3.97	18.00	1300	5	0.58
10/21/92	0.5	16.12	7.61	9.73	8.000	0.124	4.1					
10/21/92	1.0	16.08	7.60	9.64	8.010	0.124	4.1					
10/21/92	1.5	16.07	7.60	9.64	8.000	0.125	4.1					
10/21/92	1.7	16.03	7.59	9.53	7.980	0.125	4.1					

KEY:	(C) Cond D.O. (m) (mmhos/cm) ORP (ppm) (ppt) Sal TDS (V)	Celsius Conductivity Dissolved Oxygen Meters Micro-mhos per centimeter Oxygen Reduction Potential Parts per million Parts per thousand Salinity Total Dissolved Solids Volts	* Tide stage:	4 High slack	High Tide ±15 mins
				3 Late flood	1 hr 59 mins before high tide to immediately before High
				2 Max flood	3hrs 59 mins to 2hrs before high
				1 Early flood	Immediately after Low slack to 4hrs before high
				8 Low slack	Low tide ±15 mins
				7 Late ebb	1 hr 59 mins before high tide to immediately before Low
				6 Max ebb	3hrs 59 mins to 2hrs before Low
				5 Early ebb	Immediately after High slack to 4hrs before Low

CONCLUSION

The Back River system appears to be an important nursery area for striped bass, Atlantic croaker, American eel, summer flounder, white perch and spot. These six migratory species represent significantly important recreational and commercial species. The remaining migratory species play an equally important role by becoming the forage base. The system also provides the life support for numerous fresh water species that are sought for their recreational qualities, i.e. largemouth bass, catfish, yellow perch and sunfish.

The value of the system as spawning habitat for fresh water fish species is questionable. The eggs of most fresh water species are drastically affected when salinity levels are above 4.5 ppt. Salinity levels in the spring of 1991 were low enough not to interfere with hatching of the eggs. If the system were to experience a spring of low precipitation, salinity levels would rise and reproduction for fresh water species would decrease or cease.

Water quality of the entire Back River system is influenced by the James River. Due to the location of Jamestown Island, many water quality parameters will change in response to tides and/or freshwater inflow. Therefore, the results from this study only reflect the water quality at the time the measurements were taken.

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Appendix B. Fish species captured from James River (River 30-35) in vicinity of Jamestown Island, July and September (Virginia Institute of Marine Science Juvenile Striped Bass Surveys, 1969-1973, 1980-1989

Family	Species	Common name
Anguillidae	Anguilla rostrata	Eel, American
Atherinidae	Membras martinica	Silverside, rough
Atherinidae	Menidia menidia	Silverside, atlantic
Atherinidae	Menidia peninsulae	Silverside, tidewater
Belonidae	Strongylura marina	Needlefish, Atlantic
Bothidae	Paralichthys dentatus	Flounder, summer
Carangidae	Caranx hippos	Jack, crevalle
Catostomidae	Moxostoma macrolepidotum	Redhorse, shorthead
Centrarchidae	Lepomis gibbosus	Pumpkinseed
Centrarchidae	Lepomis macrochirus	Bluegill
Centrarchidae	Micropterus dolomieui	Bass, smallmouth
Centrarchidae	Micropterus salmoides	Bass, largemouth
Clupeidae	Alosa aestivalis	Herring, blueback
Clupeidae	Alosa pseudoharengus	Alewife
Clupeidae	Alosa sapidissima	Shad, American
Clupeidae	Brevoortia tyrannus	Menhaden, Atlantic
Clupeidae	Dorosoma cepedianum	Shad, gizzard
Clupeidae	Dorosoma petenense	Shad, threadfin
Cyprinidae	Cyprinus carpio	Carp, common
Cyprinidae	Hybognathus regius	Minnow, eastern silvery
Cyprinidae	Notemigonus crysoleucas	Shiner, golden
Cyprinidae	Notropis bifrenatus	Shiner, bridle
Cyprinidae	Notropis hudsonius	Shiner, spottail
Cyprinodontidae	Fundulus diaphanus	Killifish, banded
Cyprinodontidae	Fundulus heteroclitus	Mummichog
Cyprinodontidae	Fundulus majalis	Killifish, striped
Engraulidae	Anchoa hepsetus	Anchovy, striped
Engraulidae	Anchoa mitchilli	Anchovy, bay
Ictaluridae	Ictalurus catus	Catfish, white
Ictaluridae	Ictalurus nebulosus	Bullhead, brown
Ictaluridae	Ictalurus punctatus	Catfish, channel
Ictaluridae	Noturus insignis	Madtom, margined
Mugilidae	Mugil cephalus	Mullet, striped
Mugilidae	Mugil curema	Mullet, white
Percichthyidae	Morone americana	Perch, white
Percichthyidae	Morone saxatilis	Bass, striped
Percidae	Etheostoma olmstedi	Darter, tessellated
Percidae	Perca flavescens	Perch, yellow

Pomatomidae	Pomatomus saltatrix	Bluefish
Sciaenidae	Bairdiella chrysoura	Perch, silver
Sciaenidae	Leiostomus xanthurus	Spot
Sciaenidae	Menticirrhus saxatilis	Kingfish, northern
Sciaenidae	Micropogonias undulatus	Croaker, atlantic
Scrombridae	Scomberomorus maculatus	Mackerel, spanish
Soleidae	Trinectes maculatus	Hogchoker
Sparidae	Lagodon rhomboides	Pinfish
Sparidae	Stenotomus chrysops	Scup
Syngnathidae	Syngnathus sp.	Pipefish

Appendix C. Fishes captured from the James River (River mile 30-35) in the vicinity of Jamestown Island, and from Powhatan Creek from 1942 through 1978 (BOVA 1991

Species	Common name	1942	1949	1951	1953	1954	1955	1958	1964	1965	1967	1970	1975	1978
Sturgeon Family - Acipenseridae														
Acipenser oxyrhynchus	Sturgeon, atlantic	-	-	-	-	-	-	-	-	-	-	X	-	-
Bowfin Family - Amiidae														
Amia calva	Bowfin	-	-	-	-	-	-	-	-	-	-	X	-	-
Freshwater Eel Family - Anguillidae														
Anguilla rostrata	Eel, american	-	-	-	-	X	-	-	-	-	X	X	X	X
Silverside Family - Atherinidae														
Menidia beryllina	Silverside, inland	-	X	-	-	-	-	-	-	-	-	-	-	-
Needlefish Family - Belonidae														
Strongylura marina	Needlefish, atlantic	-	X	-	-	-	-	-	-	-	-	-	-	-
Sucker Family - Catostomidae														
Moxostoma macrolepidotum	Redhorse, shorthead	-	-	-	-	-	-	-	-	-	-	X	-	-
Sunfish Family - Centrarchidae														
Centrarchus macropterus	Flier	-	-	-	-	-	-	-	-	-	-	X	-	-
Enneacanthus gloriosus	Sunfish, bluespotted	-	-	-	-	-	-	-	-	-	-	X	X	-	-
Lepomis auritus	Sunfish, redbreast	-	-	-	-	-	-	-	-	-	-	X	-	-
Lepomis gibbosus	Pumpkinseed	-	-	-	-	X	-	-	-	-	X	X	-	-
Lepomis macrochirus	Bluegill	-	-	-	-	-	-	-	-	-	-	X	-	-
Micropterus dolomieui	Bass, smallmouth	-	-	-	-	-	-	-	-	-	-	X	-	-
Micropterus salmoides	Bass, largemouth	-	-	-	-	-	-	-	-	-	-	X	-	-
Pomoxis nigromaculatus	Crappie, black	-	-	-	-	-	-	-	-	-	-	X	-	-

X = Captured
- = Not Captured

Appendix C, (cont'd.) Fishes captured from the James River (River mile 30-35) in the vicinity of Jamestown Island, and from Powhatan Creek from 1942 through 1978 (BOVA 1991).

Species	Common name	1942	1949	1951	1953	1954	1955	1958	1964	1965	1967	1970	1975	1978
Herring Family - Clupeidae														
Alosa aestivalis	Herring, blueback	-	-	-	-	-	-	-	-	-	-	X	-	X
Alosa mediocris	Shad, hickory	-	-	-	-	-	-	-	-	-	-	X	-	-
Alosa pseudoharengus	Alewife	-	-	-	-	-	-	-	-	-	-	X	-	X
Alosa sapidissima	Shad, american	-	-	-	-	-	-	-	-	-	-	X	-	X
Brevoortia tyrannus	Menhaden, atlantic	-	-	-	-	-	-	-	-	-	-	-	X	X
Dorosoma cepedianum	Shad, gizzard	-	-	-	-	-	X	-	-	-	X	X	-	X
Dorosoma petenense	Shad, threadfin	-	-	-	-	-	-	-	-	-	-	X	-	-
Minnow and Carp Family - Cyprinidae														
Cyprinus carpio	Carp, common	-	-	-	-	-	-	-	-	X	X	X	-	-
Hybognathus regius	Minnow, eastern silvery	-	-	-	-	X	-	-	-	-	X	X	-	X
Notemigonus crysoleucas	Shiner, golden	-	-	-	X	X	-	-	-	-	X	X	X	-
Notropis analostanus	Shiner, satinfin	-	-	-	-	-	-	-	-	-	X	X	X	-
Notropis bifrenatus	Shiner, bridle	-	-	-	-	-	-	-	-	-	X	X	-	-
Notropis cornutus	Shiner, common	-	-	-	-	-	-	-	-	-	-	X	-	-
Notropis hudsonius	Shiner, spottail	-	-	-	-	X	X		X	-	X	X	X	X
Notropis procne	Shiner, swallowtail	-	-	-	-	-	-	-	-	-	-	X	-	-
Semotilus atromaculatus	Chub, creek	-	-	-	-	-	-	-	-	-	-	X	-	-
Killifish Family - Cyprinodontidae														
Fundulus confluentus	Killifish, marsh	-	-	-	-	-	-	-	-	-	-	X	-	-
Fundulus diaphanus	Killifish, banded	-	-	-	-	-	-	-	-	-	-	X	X	-	-
Fundulus heteroclitus	Mummichog	-	X	-	-	-	-	-	-	-	-	X	X	-	-
Anchovy Family - Engraulidae														
Anchoa mitchilli	Anchovy, bay	-	-	-	-	-	-	-	-	-	-	-	X	-
Pike Family - Esocidae														
Esox americanus	Pickerel, redfin	-	-	-	-	-	-	-	-	-	-	X	-	-
Esox niger	Pickerel, chain	-	-	-	-	-	-	-	-	-	-	X	-	-
Stickleback Family - Gasterosteidae														
Gasterosteus aculeatus	Stickleback, threespine	-	-	-	-	-	-	-	-	-	-	X	-	-
Catfish Family - Ictaluridae														
Ictalurus catus	Catfish, white	X	-	-	-	-	-	-	-	-	X	X	-	X
Ictalurus nebulosus	Bullhead, brown	X	X	-	-	-	-	-	-	-	X	X	-	
Ictalurus punctatus	Catfish, channel	X	-	-	-	-	X	-	-	-	X	X	-	X

Gar Family - Lepisosteidae

Lepisosteus osseus Gar, longnose - - - - - - - - - - X - -

Temperate Bass Family - Percichthyidae

Morone americana Perch, white X - X X X - - - X X - X
Morone saxatilis Bass, striped X - X X X - - - X X - X

Perch Family - Percidae

Etheostoma olmstedi Darter, tessellated X - - - X - - - X X - X
Perca flavescens Perch, yellow - - - - - - - - X X - X

Lamprey Family - Petromyzontidae

Lampetra aepyptera Lamprey, least brook - X - - - X - - - - - -
Petromyzon marinus Lamprey, sea - - - - - - - - - X - -

Livebearer Family - Poeciliidae

Gambusia affinis Mosquitofish - - - - - - - - - X - -

Mudminnow Family - Umbridae

Umbra pygmaea Mudminnow, eastern - - - - - - - - - X - -

X = Captured
- = Not Captured

FISHERY INVENTORY AND BASELINE WATER QUALITY COLLECTED AT CHEATHAM ANNEX NAVAL SUPPLY CENTER WILLIAMSBURG, VIRGINIA

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ABSTRACT

Baseline information concerning the quality, size distribution and abundance of sportfishes and water quality parameters at Cheatham Annex, Virginia was collected April 15-19 and May 5, 1994. Data analyzed from collections obtained at Cheatham Lake, Penniman Lake and Jones Pond indicated that the base has a reasonably healthy sportfish population. All impoundments sampled contained largemouth bass and bluegill, while redear sunfish, pumpkinseed and black crappie occurred in some lakes and not others. No threatened or endangered fish species were collected. Water quality parameters were generally within acceptable boundaries, however, pH values were near the high end of preferred limits in all impoundments and dissolved oxygen was below preferred values in Cheatham Lake.

INTRODUCTION

Surveys of the fishery resource inhabiting the impoundments located within the boundaries of Cheatham Annex are necessary for effective and meaningful management strategies. As such, Cheatham Annex entered into an Inter-Service Support Agreement with the U.S. Fish and Wildlife Service (Service) and requested therein that the Service conduct fish surveys and water quality analyses of the three primary fishing impoundments on Cheatham Annex. Information collected will be valuable to Cheatham Annex when developing a management plan for this heavily used resource.

STUDY AREA

Impoundments surveyed during the present study included Jones Pond, Cheatham Lake and Penniman Lake. These impoundments range in size from approximately 40-70 acres and are open to fishing on a basewide (Penniman) and public (Jones, Cheatham) basis. Shorelines are vegetated and curly pondweed is the predominant aquatic vegetation. Algae blooms are controlled by copper sulfate in Jones Pond (the base water supply), while aquatic vegetation is annually controlled at the discretion of the Resource Manager (Diquat). A complete site description may be found in the Fish and Wildlife Management section of the Cheatham Annex Natural Resource Plan (1988).

MATERIALS AND METHODS

All impoundments were sampled with a gasoline powered electro-fishing shocker boat. Fishes were collected by dipnet and identified to species, measured, weighed and released.

A Hydrolab Surveyor II water quality meter was used to collect data at three individual stations in each impoundment for water temperature, pH, Oxidation-Reduction Potential, dissolved oxygen (DO), percent oxygen saturation, conductivity and salinity.

Electro-fishing occurred at 1 h intervals and 2-3 complete hrs was considered sufficient for a representative fish sample. Fishes were obtained along shorelines or at known, fish

aggregating locations (i.e., submerged brushpiles).

DATA ANALYSIS

Collections of fishes at individual impoundments were summarized by total number (n), average length and average weight based on the size criteria of Proportional Stock Density (PSD) (Kohler and Hubert 1993) (see Appendix A). The categories of PSD are based on percentages of world record lengths and take into account the interaction of reproduction, growth and mortality. Fishes of "Quality" size or larger, are considered to be the size that most anglers like to catch, while "Stock" size is the size at or near sexual maturity. Fishes less than the minimum size for "Stock" density are considered juveniles and are represented as "Other" in Tables 3 and 4 of this report. Some species (i.e., Warmouth and Brown Bullhead) do not have size designations developed for them and only occur in the general species composition list (Table 1). Abbreviations for all fishes collected at Cheatham Annex are defined in Appendix B.

Relative weight (W_{rel}) is a common measure of fish health/quality that may be calculated using a simple logarithmic equation generated from linear regression. Fish length and weight are the only required variables. Values of W_{rel} permit comparisons with fishes from other populations (all over the country). While these equations have been developed for a number of species, largemouth bass and bluegill are the only fishes that occur in base waters that have equations developed for them. Fortunately, these two species are the most common in base waters. Fish with W_{rel} near 100 are considered to be in balance with their food supply. Fish with values below 85 are underweight, indicating that they may be too abundant for their food supply. Fish with values exceeding 105 are better fed than necessary, reflecting an over-abundant food supply. Consequently, when W_{rel} are high (> 105) the impoundment does not meet its' carrying capacity and could support more fish without detrimental effects. However, for a trophy bass fishery, values exceeding 100 may be preferred. Relative weights were calculated on all largemouth bass and bluegill collected to compare fish of each size class both within and among each sampling location.

RESULTS

Fish Community Structure - Samples collected during April 14-19, 1994 at each impoundment resulted in the collection or observation of 11 species of fishes (Table 1). Overall species diversity was not surprising at any of the three impoundments. Since small minnow-type fishes were not as vulnerable to the electro-shocker, all species of forage fishes may not have been collected. Gizzard shad and golden shiner were collected in Cheatham and Penniman Lake, while few, if any, of these species were seen in Jones Pond. All ponds contained numerous American eels. Largemouth bass and bluegill were the numerically dominant species at all sites. Striped bass and Striped bass X White bass hybrids had historically been stocked in Cheatham Lake but were not found during this survey.

Gamefishes collected at all impoundments were summarized by total number, average length and weight for each of the Preferred Stock Density (PSD) size classes (Table 2A-C). Overall, gamefish at Cheatham Annex fell into 3 categories, "Stock" "Quality" and "Preferred."

Only one "Memorable" sunfish, a bluegill, and two "Memorable" black crappie were collected in Penniman Lake. No "Trophy" fish of any species were collected at any impoundment.

Large differences in the size structure of fishes between impoundments were not evident with the exception of the smaller average size and weight of bluegill in Jones Pond. "Preferred" size LMB was most abundant in Cheatham and Penniman Lakes and "Memorable" LMB occurred more frequently in Cheatham Lake. All three impoundments appeared to have good population densities of "Stock" and "Quality" size fish.

Catch Per Unit Effort (CPUE).- Catch per unit effort calculated for all gamefish species (with total number > 4) indicated that largemouth bass and bluegill had the densest populations in all three impoundments (Table 3). A CPUE value of 100 or greater is considered to be indicative of a dense largemouth bass population. With this in mind, Jones Pond contained the densest bass population for "Stock" size or better fish. However, Jones Pond also contained the least dense BLG population. Redear Sunfish (Cheatham Lake), were the only other species to have a CPUE greater than 10. These results may be slightly biased due to our concentration on collecting LMB and large sunfish.

Relative Weights - Relative weights for largemouth bass and bluegill at the three impoundments provided a measure of comparative fish health and are summarized in Table 4. Overall, largemouth bass appeared to be in best condition in Cheatham Lake. Large LMB, those "Quality" size or larger, were generally in better condition than smaller fish. However, the observation that many of the large LMB collected were reproductively active may bias these results on the high side. Regardless, these fish appeared to be in very good condition. Bluegill populations were determined to be in good condition in both Penniman and Cheatham Lake but were in poor condition in Jones Pond.

Water Quality - Measurements of water quality parameters (Table 5) during the sampling period (May 5, 1994) indicated that conditions are generally favorable for the growth and reproduction of the fishes present at Cheatham Annex.

Dissolved Oxygen (DO) values at the surface, ranged from 3.45 ppm at Cheatham Lake to 8.00 ppm at Penniman Lake. Values measured at or near bottom (1.6-4.7 m) ranged from 2.22 ppm. at single stations in Cheatham Lake and Jones Pond to 7.14 ppm. at 3.5 m in Jones Pond. Under normal conditions, 3.0 ppm of dissolved oxygen, or less, should be regarded as hazardous or lethal to fish. Dissolved oxygen from 6.0 to 9.0 ppm is ideal for the fish communities present and these conditions were observed in Penniman Lake and Jones Pond but were not measured in Cheatham Lake. The pH values of most inland waters containing fish range between 6.7 and 8.6 and most fishes do well under a wide pH range (4.7-8.7). All of the impoundments sampled fell within these limits, however, average pH at all ponds was near the high end of this range. Values of salinity and conductivity, as expected, were near zero at all sample locations and depths.

DISCUSSION

Largemouth Bass (LMB) - The collection of numerous young of the year LMB, indicates that all impoundments support a good quality, reproductively active population. While no

"Trophy" fish were observed, it is unlikely that none occur in base waters. The distribution of sizes among the three impoundments were similar. Cheatham and Penniman Lakes, however, contained a large number of "Quality" and larger fish, while Jones Pond contained relatively few. Examination of W_{rel} for each size class suggests that, on average, LMB in Cheatham Lake are the healthiest, being in good balance with their food supply. This finding is not surprising when considering the abundant forage present in Cheatham Lake. Penniman Lake contained a less dense forage fish population and W_{rel} for LMB were lower. Relative weights for "Stock," "Quality" and "Other" LMB in Penniman Lake were borderline underweight, indicating that these fish may be putting a high demand on their food supply. Jones Pond, also revealed a LMB population that appears to be stressing its' food supply. Though not quantitative, results of the survey revealed very few forage species and those that were present (predominately BLG) were in very poor condition. Numerous, juvenile LMB were collected in Jones Pond and these may be acting as forage for the larger LMB.

Bluegill (BLG) - Bluegill populations in all three impoundments appeared to be either stunted or over-fished. While CPUE was fairly high in Cheatham Lake, collections in Jones Pond and Penniman Lake were meager. Size distribution of bluegills was also skewed heavily in favor of small fish with only 1 "Preferred" and 1 "Memorable" fish collected out of all sites (n = 188). While we were unable to dip all small BLG, large fish were targeted but simply not seen. Relative weights indicated that the condition of small fish ("Other") was extremely good and "Stock' and Quality" size fish appeared to be in good condition in both Penniman and Cheatham Lakes. Condition of "Stock" and larger bluegills in Jones Pond, however, was poor.

Redear Sunfish (RES).- Although RES were collected in both Cheatham Lake and Jones Pond, only Cheatham Lake contained a relatively dense population. The opportunity for catching a "Memorable" or "Trophy" fish probably exists in Cheatham Lake, however, no fish of this size were collected in the survey. Redear sunfish are probably important forage for LMB where they occur, especially Jones Pond.

Black Crappie (BLC).- Black crappie only occurred in Cheatham and Penniman Lakes. While good catches reportedly occur (Resource Manager, personal communication), population densities based on CPUE were low. Most BLC occurred in or around structure (brushpiles) and may have been suspended in waters too deep for the electro-shocking gear to effectively sample. The potential for a good fishery certainly exists, as evidenced by at least two "Memorable" class fish taken off structure in Penniman Lake.

Other Gamefish (BBH and PSS).- Pumpkinseed sunfish were only collected at Penniman Lake and occurred at low density. Brown Bullhead were collected/observed in Penniman Lake and Jones Pond, however, densities were low and these fish are probably not the focus of a directed fishery.

Forage Fish (GOS, GZS, SIL).- Forage fish species were abundant in Cheatham Lake but were less abundant or scarce in both Jones Pond and Penniman Lake. These conditions may partly explain why Cheatham Lake LMB were in superior condition. Additionally, abundant forage may explain the apparent difficulty in angling for LMB in Cheatham Lake.

Water Quality - Water quality of Cheatham Annex impoundments was suitable for fish growth and health, however, pH values were near the preferred maximum at some stations. Detrimental oxygen values were only recorded very near bottom at the deepest station sampled in Jones Pond. No oxygen minima (values < 3.0 ppm) were measured in Penniman Lake. Dissolved oxygen at Cheatham Lake, however, was much lower than the other two impoundments, conditions that may be reflective of recent Diquat treatments that removed the oxygen producing plants. Most likely, these conditions will correct themselves as Penniman Lake had also undergone Diquat treatment within 14 days of these samples and had apparently recovered nicely.

RECOMMENDATIONS

CHEATHAM LAKE.- To improve angling success for LMB, reduction of the standing stock of forage species is recommended. This may be accomplished by removing panfish either by:
1) small, basewide tournaments; 2) electro-fishing and removing a proportion of all forage species; and/or 3) a winter water drawdown of 2-3 feet to help reduce forage species which may help increase the size of all fish. Attempts to improve GZS and GOS populations in Jones Pond and Penniman Lake may be attempted using fishes removed from Cheatham Lake. Since large panfish appear to be over-fished, tournaments may be the least effective alternative. To improve the stock density of "Preferred" and larger panfish, a catch and release fishery may be established for a period of time to determine if panfish have the potential to reach large sizes in Cheatham Lake.

PENNIMAN LAKE.- Largemouth bass appear to be in relatively good condition, however, additional forage species or greater densities of established forage species may improve existing conditions. This condition could be mediated with fishes from Cheatham Lake.

JONES POND.- Largemouth bass appear to be stunted and in low condition due to the scarcity of forage. The low condition index for bluegill, however, precludes stocking more until the reason for their condition is established. While predation is certainly limiting the number of bluegill and other forage species (i.e., WAR, PSS, RES), it can not explain their poor condition. Whether food, cover or both is inadequate is unknown but is probably a combination of the two. Recommendations include the stocking of gizzard shad or some other forage to improve the condition of LMB.

OVERALL.- A late-spring, post-spawning follow up survey is recommended, at least on Jones Pond, to re-evaluate fish condition and further monitor the panfish population. Ideally, however, recommendations should be implemented and a follow-up on all three impoundments be conducted by early summer 1995. Additionally, further monitoring of water quality (primarily pH and dissolved oxygen) is recommended.

APPENDIX B. Abbreviations for fishes collected within the Cheatham Annex Naval Supply Center, April 1994.

LMB- Largemouth Bass
BLG- Bluegill
BLC- Black Crappie
RES- Redear Sunfish
PSS- Pumpkinseed
BBH- Brown Bullhead
GZS- Gizzard Shad
AME- American Eel
SIL- Tidewater Silverside
WAR- Warmouth
MIC- Mirror Carp
GOS- Golden Shiner

A Qualitative Inventory of the Fisheries Resources and Baseline Water Quality Parameters in the Tidal Environment of the Colonial National Historical Park, Virginia

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Abstract

A qualitative inventory of the fisheries resources and baseline water quality parameters of waters within and adjacent to three portions of Colonial National Historical Park (COLO), Virginia, was conducted in 1994-1997 by the U.S. Fish and Wildlife Service. The water bodies surveyed included: 1) Wormley Pond, a shallow freshwater impoundment in the Yorktown area; 2) Black Duck Gut and the near-shore areas of the James River in the Swann's Point area; and 3) College Creek and Halfway Creek in the Kingsmill Neck area. This completes a 10-year effort to survey the fisheries resources and baseline water quality parameters in waters throughout COLO.

Wormley Pond, a non-fished impoundment that is spring fed, supports an assemblage of six common native North American fishes, including the migratory American eel. Largemouth bass are exceptionally abundant and stunted, and the bluegill population is average compared to other Virginia small impoundments. No federal or state listed threatened, endangered, or candidate (for listing as endangered or threatened) species were observed. With the exception of pH, the water quality in Wormley Pond is typical for a pond in eastern Virginia. The pH (median value of 7.42) is higher than many coastal plain ponds, probably as a result of the fossiliferous soils (Yorktown formation) found in the Yorktown area.

The results of this survey indicate that the productive estuarine waters at the Swann's Point and Kingsmill Neck areas contain a diverse community of 23 resident and 13 migratory fish species, 15 of which are of commercial and recreational importance. Atlantic menhaden, white perch, mummichog, inland silverside and gizzard shad were the dominant fishes in our samples. Only one exotic was encountered: the ubiquitous common carp. No federal or state listed threatened, endangered, or candidate (for listing as endangered or threatened) species were observed. The water quality appeared to be well suited to providing quality nursery habitat for the numerous fishes of ecological, commercial, and recreational importance found at Swann's Point and Kingsmill Neck.

Baseline water quality and fisheries resources should be resurveyed on a ten-year rotational basis throughout COLO; a level of monitoring that would be adequate for most water bodies within the park. For water bodies prone to significant degradation or overfishing, a more frequent monitoring schedule (five-year rotational basis) may be desirable. COLO should consider intensifying water quality monitoring efforts to document nutrient levels and sources for any waters prone to nutrient enrichment from land-use outside the park.

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Introduction

This report addresses work conducted by the U.S. Fish and Wildlife Service (USFWS) during 1994-1997 to fulfill obligations to Amendment Number 1 (dated 1 August 1994) and Amendment Number 2 (dated 4 October 1996) to Interagency Agreement 4000-1-0007 between the National Park Service (NPS) and USFWS. The amendments requested that the USFWS conduct a qualitative inventory of the fisheries resources and baseline water quality parameters in the tidal environment of portions of the Colonial National Historical Park (COLO) in Virginia. The water bodies surveyed included: 1) Wormley Pond in the Yorktown area; 2) Black Duck Gut and the near-shore areas of the James River in the Swann's Point area; and 3) College Creek and Halfway Creek in the Kingsmill Neck area. This report, combined with two previous efforts by the USFWS (USFWS 1988; Swihart et al. 1992), completes a 10-year effort to survey the fisheries resources and baseline water quality parameters in waters of COLO.

The natural resources database for COLO has limited baseline water quality and fish species occurrence data for the tidal waters of the park. Such information is essential to enable COLO to evaluate and monitor its natural resources program and to evaluate impacts to its aquatic resources due to pollution and off-site changes in land use practices. The USFWS designed a study to collect baseline water quality data and sample the fish communities of the target water bodies. The USFWS Virginia Fisheries Coordinator conducted the survey of the estuarine waters in the Swann's Point and Kingsmill Neck areas, and results of this effort are presented in Part I of this report. Part II addresses the sampling of Wormley Pond, a freshwater impoundment near Yorktown, conducted by the USFWS Office of Fishery Assistance at Gloucester. Recommendations for future monitoring of aquatic resources within COLO follow Part II.

Part I: Swann's Point and Kingsmill Neck

Study Area

Swann's Point is located on the south side of the James River in Surry County, Virginia, across the river from Jamestown Island. The estuarine James River borders the COLO parcel at Swann's Point to the north and east. In addition, a small tidal creek called Black Duck Gut flows from a marsh on the eastern portion of the COLO parcel. Tidal fluctuations at Swann's Point are approximately two feet. The substrate in the James River at Swann's Point is primarily sand and hard clay. The substrate in Black Duck Gut is muck. Water quality and fish community sampling at Swann's Point was conducted in both Black Duck Gut and the near-shore areas of the James River.

Kingsmill Neck is located in James City County, Virginia, approximately four kilometers south of Williamsburg. The COLO parcel on Kingsmill Neck borders significantly on College Creek to the south and west of the parcel, as well as Halfway Creek on the northern edge of the parcel. College Creek is a tidal tributary of the James River and its watershed encompasses the majority of the City of Williamsburg. Halfway Creek is a tidal tributary of College Creek and drains a significant upland area, including two large residential developments (Kingsmill and Kingspoint). Tidal fluctuations at Kingsmill Neck are approximately two feet. The substrate in

College Creek and Halfway Creek is comprised of muck, hard clay and sand. Water quality and fish community sampling at Kingsmill Neck was conducted in those portions of College Creek and Halfway Creek that border COLO property.

Methods

Swann's Point and Kingsmill Neck border the estuarine James River and associated tidal tributaries. Daily tidal fluctuations and changes influence these dynamic water bodies significantly in salinity throughout the year. Salinities may range from freshwater in the late-winter and spring months, to 9.0+ ppt (parts per thousand) in the late summer and fall. These significant shifts in salinity not only influence the fish species composition seasonally, but also have a direct bearing on the gear types that can be used to sample the fish community. Generally, electrofishing is a relatively effective sampling method for surveying fish communities. However, during September and October 1995, salinities were too high for electrofishing gear to be effective. Consequently, USFWS personnel used a variety of other gears to sample multiple habitat types for this survey: trap nets, horizontal gill nets, seine, trawl and minnow traps. To reflect the seasonal changes in water quality variables and the fish community at Swann's Point and Kingsmill Neck, sampling was conducted during both the fall and spring.

Water quality parameters were measured in the field. A 20-cm diameter Secchi disk was used to measure water transparency, which was reported to the nearest 0.1 meter. Water quality parameters for salinity, oxidation reduction potential, conductivity, total dissolved solids, dissolved oxygen, pH, and water temperature were measured from the surface to the bottom at 0.5-meter intervals with a Hydrolab Surveyor 3 water quality meter. For each station profile, the air temperature, tidal stage and time of day (to the nearest five minutes) were recorded.

Single-lead trap nets were set perpendicular to the shoreline with the net lead tied to an anchor on shore, and the trap in deeper water. Trap nets were set to fish for a time period of approximately 24 hours.

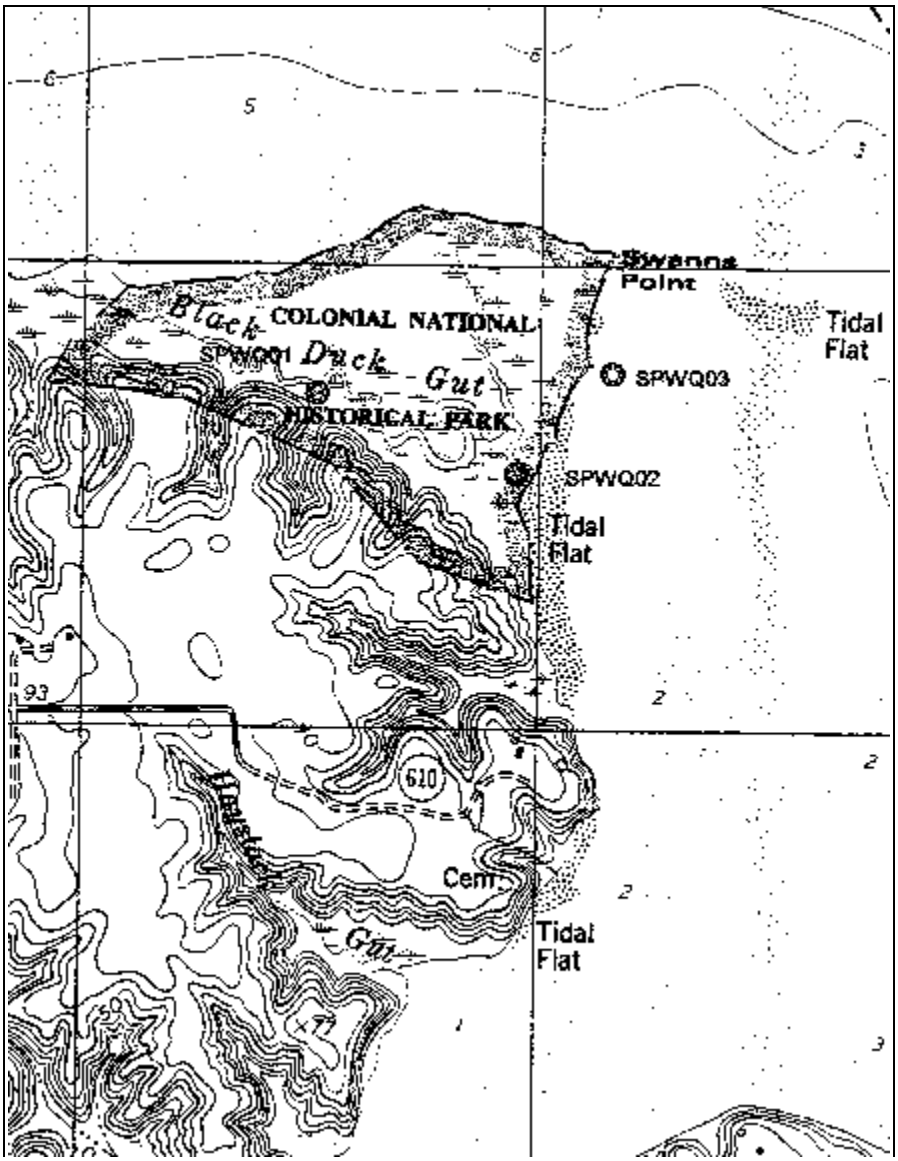
Horizontal, five-panel experimental (3.8, 5.1, 6.4, 7.6, and 8.9-cm stretch meshes) sinking gill nets with a length of 38.10 m and a depth of 2.44 m were set perpendicular to the shoreline with the small-mesh end tied along the shore, and the large-mesh end anchored in deeper water. The gill nets were set to fish for a period of approximately three hours, bracketing either high or low tide.

A bag seine (15.24 m X 1.22 m) with a mesh size of 12.7 mm, and a bag liner mesh size of 6.4 mm, was used to sample near-shore habitats that had a hard bottom and few obstructions. Two people operated the seine during daylight hours. One individual hauled one end of the seine out from shore to deeper water while the other operator stayed in shallow water close to the bank. The seine was then pulled parallel to the shore a short distances (approximately 50 meters) against the tidal flow (if present). The individual adjacent to the shore then stopped and the channelward operator then brought his end of the net in an arc back to the shore, encircling the fish. The seine was then pulled slowly out of the water onto the bank.

A bottom trawl was utilized to collect fish in the deeper, open-water habitat at the sampling areas. The trawl used was a 3.3-m (size of the mouth opening of the net) shrimp trawl constructed from 33-mm stretch mesh nylon netting. The codend (back-end) of the net contained a 3-mm stretch mesh nylon liner to prevent small fish from passing through the net. A weighted otter board (61 cm X 31 cm) was attached to each side of the trawl net to keep the net mouth open while being towed, and to keep the trawl down along the bottom. The trawl was towed for 10 minutes at each sampling site at a speed of approximately 4.25 km/hour, against the tidal flow.

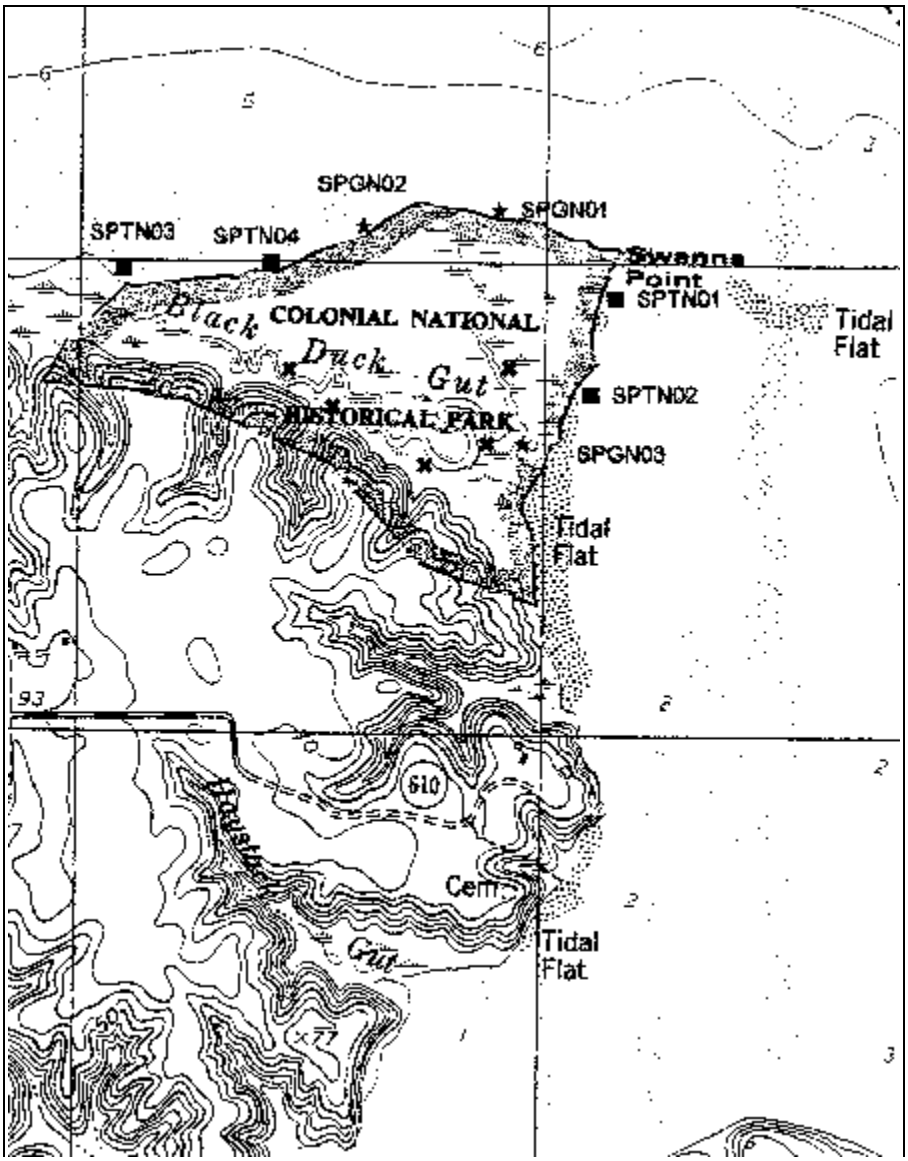
Plastic cylindrical minnow traps (43 cm X 22 cm, with a throat opening of 3 cm) were used to sample shallow water habitats within and adjacent to estuarine emergent wetlands (Cowardin et al. 1979). The traps were baited with dry dog food to attract fish, anchored in place, and fished for a period of approximately 24 hours.

The Swann's Point area was sampled during the following dates: 27-28 September 1995 (fall sampling), and 9-29 May 1996 (spring sampling). All water quality and fish collection sites were sampled once per season. Water quality parameters were measured at two locations on Black Duck Gut and one location on the James River (Figure 1.1). Five minnow traps were set along Black Duck Gut (Figure 1.2). Three anchor gill nets were set: one in the lower end of Black Duck Gut, and two in near-shore habitats of the James River (Figure 1.2). Four trap nets were set in near-shore habitats of the James River (Figure 1.2), and haul seine samples were made at three locations along the James River shoreline (Figure 1.3). An otter trawl was towed at two locations in near-shore waters of the James River (Figure 1.3).



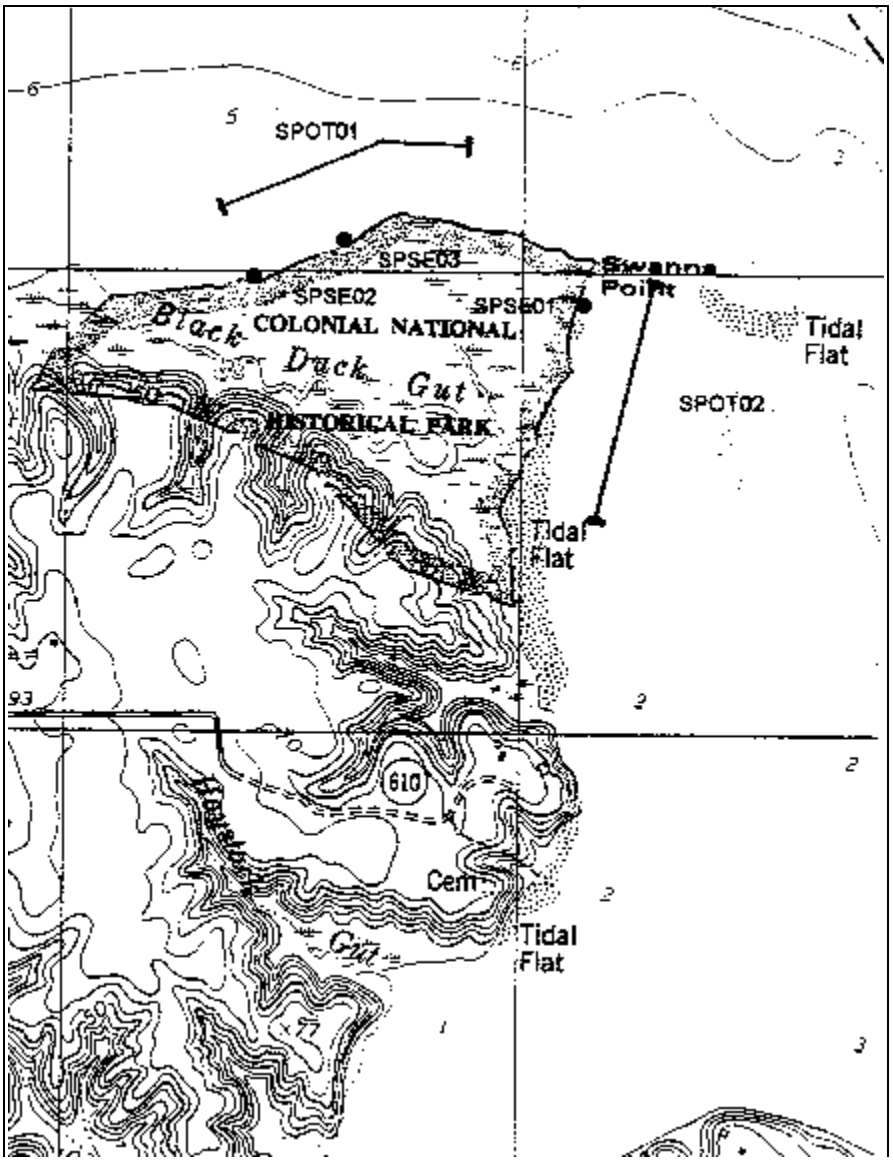
Water quality sampling station

Figure 1.1. Water quality monitoring stations sampled in Fall 1995/Spring 1996 at the Swann's Point area.



= Minnow trap sampling site
= Gill net sampling site
= Trap net sampling site

Figure 1.2. Location of minnow trap, gill net, and trap net sampling sites utilized in Fall 1995/Spring 1996 to survey the fishery resources at the Swann's Point area.



= Otter trawl sampling site
= Seine sampling site

Figure 1.3. Location of otter trawl and seine sampling sites utilized in Fall 1995/Spring 1996 to survey the fishery resources at the Swann's Point area.

The Kingsmill Neck area was sampled during the following dates: 2-4 October 1995 (fall sampling), and 13-30 May 1996 (spring sampling). All water quality and fish collection sites were sampled once per season. Water quality parameters were measured at three locations on Halfway Creek and three locations on College Creek (Figure 1.4). Fish sampling in Halfway Creek included the setting of five minnow traps, three anchor gill nets and four trap nets (Figure 1.5). Fish sampling in College Creek utilized five minnow traps, three anchor gill nets, and four trap nets (Figure 1.5), as well as two seine hauls at the mouth of the creek, and three trawl samples (Figure 1.6). The seine was not used in Halfway Creek due to the absence of a suitable seining site, and the abundance of underwater obstructions (logs, submerged pilings, etc.) prohibited effective use of a trawl.

All fishes captured were identified to species (or lowest taxonomic level), measured (total length), weighed, and returned to the river. An exception to this is that group weights (instead of individual weights) were taken on some of the smaller fishes. Notable non-target organisms (species other than fish) that were captured during sampling were recorded and reported in this document (see Page 17).

Results

The results of this survey indicate relatively good water quality for the maintenance of a diverse fish community (Table 1.1). Salinity, total dissolved solids and conductivity varied significantly between seasons. This is attributed to seasonal changes in freshwater discharge upriver, as these three water quality parameters are influenced strongly by dissolved salts originating from seawater. In the spring when freshwater discharge of the James River basin was relatively high, the influence of seawater in this part of the estuary was minor and salinity values were relatively low (0.2-0.5 ppt), as were total dissolved solids (209-570 mg/L) and conductivity (0.33-0.89 mmhos/cm). In the fall, freshwater discharge was low and dissolved salts were higher, resulting in elevated salinity (6.2-8.9 ppt), total dissolved solids (6,925-9,856 mg/L), and conductivity (10.82-15.40 mmhos/cm).

A total of 3,058 fish were captured representing 36 species (Table 1.2), including the following important commercial and recreational fishes: American eel (*Anguilla rostrata*), American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), and southern flounder (*Paralichthys lethostigma*). This diverse mixture of fishes is typical for upper estuarine habitat due to the seasonal changes in salinity that occur. The five most abundant species in our samples were Atlantic menhaden, white perch, mummichog (*Fundulus heteroclitus*), inland silverside (*Menidia beryllina*), and gizzard shad (*Dorosoma cepedianum*). The only unusual fish captured was one southern flounder collected in College Creek in October 1995. Southern flounder are rarely encountered in the Chesapeake Bay, typically venturing no farther north than coastal North Carolina. The hot summer weather of 1995 may have allowed this individual to roam farther north than usual. None of the fishes captured in this survey are listed as threatened,

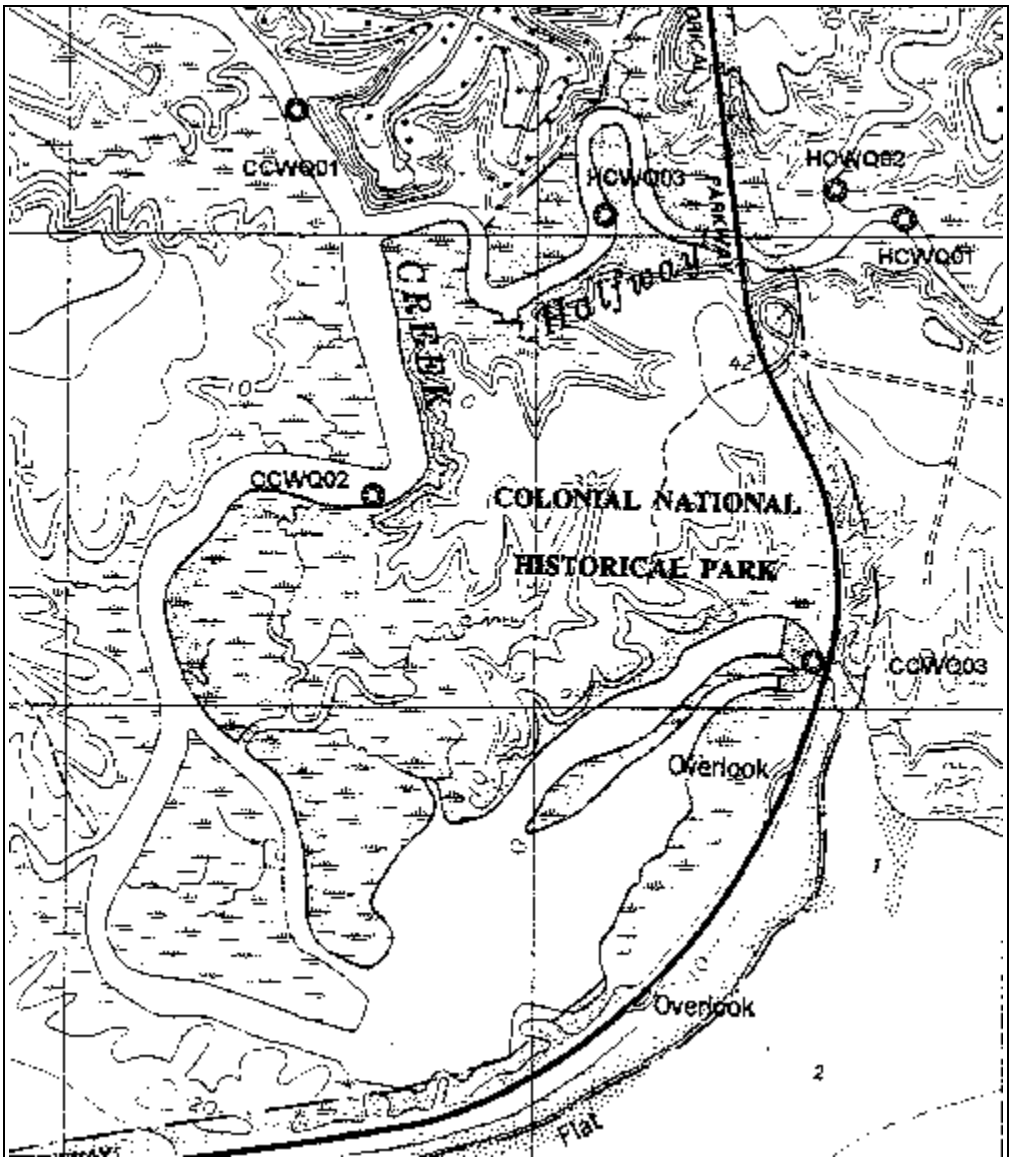
endangered, or candidate species by either the USFWS or Virginia Department of Game and Inland Fisheries (VDGIF).

Only one exotic fish species was observed during sampling: the ubiquitous common carp (*Cyprinus carpio*) which was introduced into Virginia in 1880 (Jenkins and Burkhead 1993). Five species that we have labeled "native" (Table 1.3) are indigenous to North America but have been introduced to the James River drainage within the last 150 years (Jenkins and Burkhead 1993): threadfin shad (*Dorosoma petenense*), blue catfish, channel catfish, bluegill, and largemouth bass. While all of these introduced fishes have successfully colonized aquatic habitats in Virginia, they are not regarded as nuisance species. The blue catfish is relatively new to the James River drainage and the ecological impacts of this introduction are still being assessed. The blue catfish appears to be displacing channel catfish (an earlier introduction) from deeper channel habitats, and diet studies indicate that they prey mostly on gizzard shad and white perch, both of which are very abundant.

Thirteen of the fish species captured are migratory (Table 1.3), with juveniles of many species using the productive estuarine waters adjacent to COLO as a nursery. For the purpose of this report, we define "migratory fish" as those species that move out of the James River drainage during their life cycle.

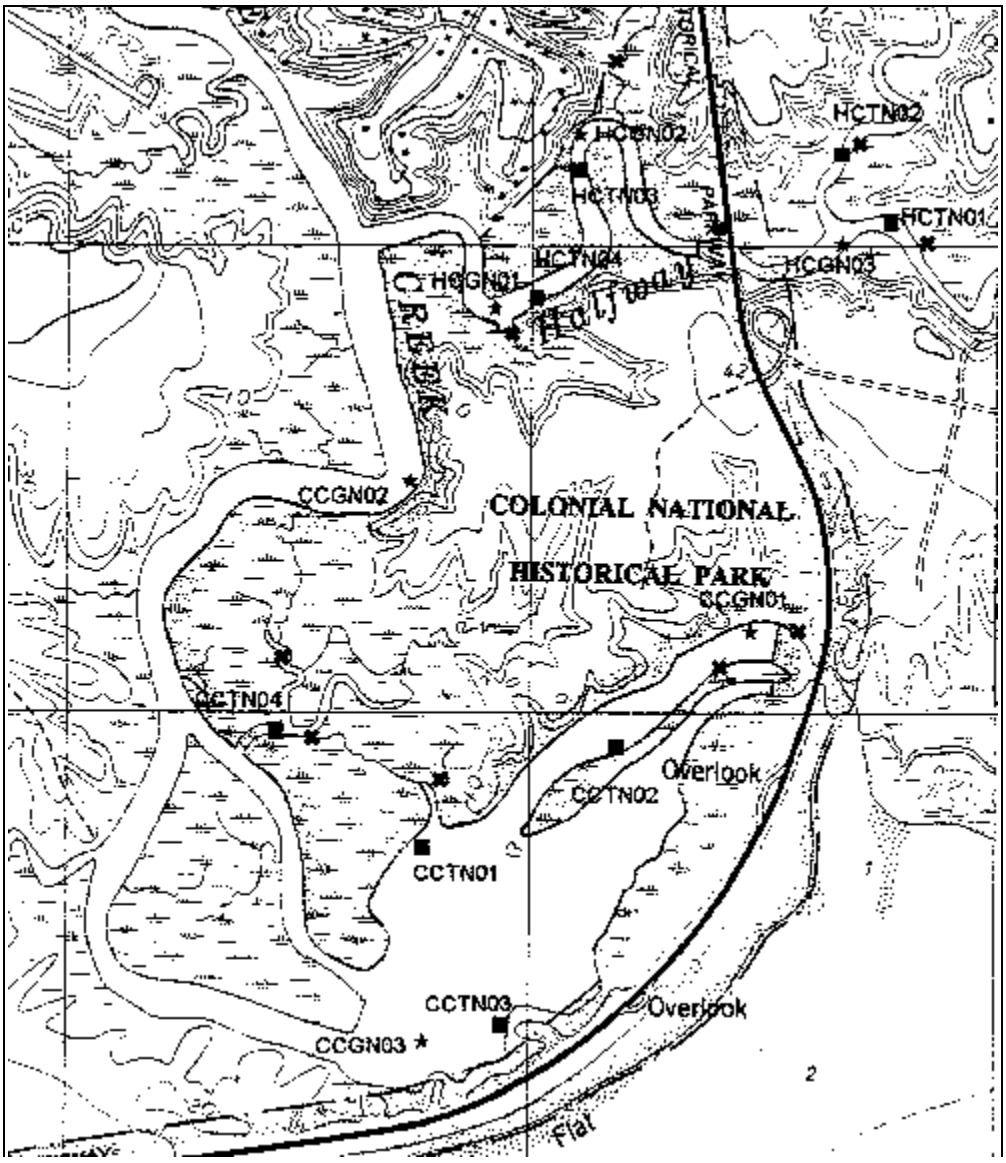
In addition to the fishes captured, the commercially and recreationally important blue crab (*Callinectes sapidus*) was encountered at all sites sampled. Another commercially important crustacean, white shrimp (*Penaeus setiferus*), was observed and captured in significant numbers in both College Creek and Halfway Creek. Four adult red-bellied turtles (*Chrysemys rubiventris*) were collected in the upper portion of Halfway Creek. This large basking turtle is common in the tidal rivers of Virginia. Four diamondback terrapins (*Malaclemys terrapin*), a less common reptile, were captured in the lower portion of College Creek.

In summary, the estuarine waters bordering COLO support a diverse fish assemblage and provides important nursery habitat for numerous fishes of ecological, commercial, and recreational importance.



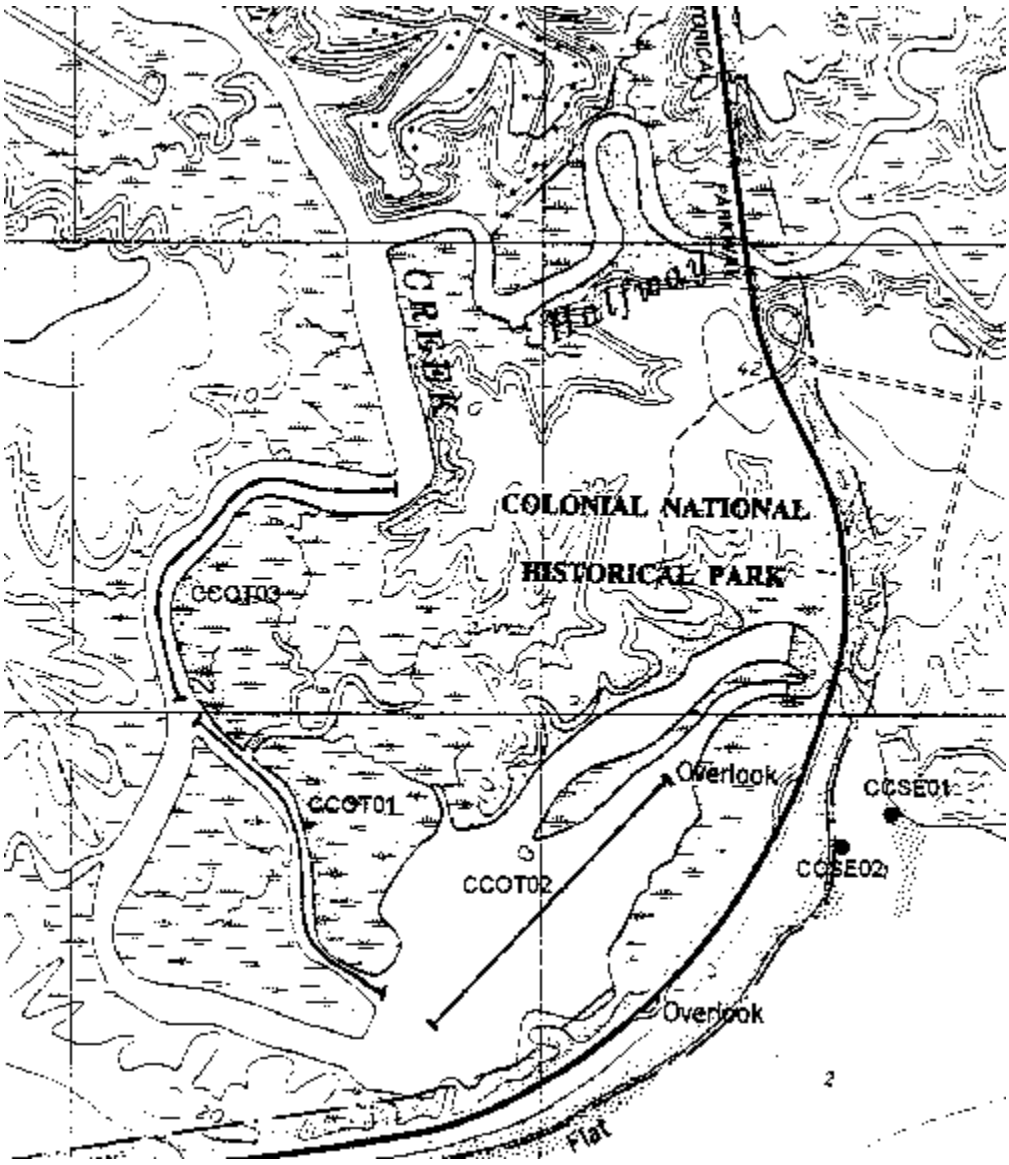
= Water quality sampling station

Figure 1.4. Water quality monitoring stations sampled in Fall 1995/Spring 1996 at the Kingsmill Neck area.



= Minnow trap sampling site
= Gill net sampling site
= Trap net sampling site

Figure 1.5. Location of minnow trap, gill net, and trap net sampling sites utilized in Fall 1995/Spring 1996 to survey the fishery resources at the Kingsmill Neck area.



= Otter trawl sampling site
= Seine sampling site

Figure 1.6. Location of otter trawl and seine sampling sites utilized in Fall 1995/Spring 1996 to survey the fishery resources at the Kingsmill Neck area

Table 1.1. Water quality values measured in waters at Swann's Point and in the Kingsmill Neck area, in Fall 1995 and Spring 1996

Station	Date	Time (24-hour)	Tide Stage Code (1)	Air Temperature (Celsius)	Secchi Disk (meters)	Depth (meters)	Total Dissolved Solids (mg/L)	Salinity (ppt)	Oxidation Reduction Potential (millivolts)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH	Water Temperature (Celsius)	Remarks
CCWQ01	05/30/96	1515	3	21.6	0.50	0.0	452	0.4	405	0.71	8.12	7.63	20.35	Surface
College Creek	Spring					0.5	452	0.4	402	0.71	7.95	7.61	20.22	
(Upper)						1.0	452	0.4	402	0.71	7.95	7.62	20.22	
						1.5	452	0.4	401	0.71	7.94	7.60	20.22	
						2.0	452	0.4	401	0.71	7.88	7.61	20.21	
						2.5	452	0.4	400	0.71	7.89	7.61	20.22	Bottom
	10/02/95	1125	7	25.8	0.50	0.0	8550	7.7	264	13.36	6.75	7.05	21.02	Surface
	Fall					0.5	8550	7.7	266	13.36	6.61	7.04	20.95	
						1.0	8550	7.7	266	13.36	6.59	7.03	20.93	
						1.5	8557	7.7	267	13.37	6.51	7.03	20.93	
						2.0	8563	7.7	268	13.38	6.50	7.03	20.95	Bottom
CCWQ02	05/30/96	1530	3	21.6	0.50	0.0	459	0.4	419	0.72	7.39	7.50	20.03	Surface
College Creek	Spring					0.5	458	0.4	416	0.72	7.40	7.50	20.07	
(Middle)						1.0	458	0.4	415	0.72	7.29	7.49	20.02	
						1.5	458	0.4	415	0.72	7.23	7.49	19.98	
						2.0	458	0.4	414	0.72	7.25	7.49	20.00	
						2.5	459	0.4	413	0.72	7.29	7.49	19.98	
						3.0	458	0.4	412	0.72	7.25	7.49	19.98	
						3.5	458	0.4	412	0.72	7.24	7.49	20.00	
						4.0	457	0.4	411	0.71	7.26	7.49	19.98	
						4.4	458	0.4	411	0.72	7.26	7.49	20.00	Bottom
	10/02/95	1135	7	25.9	0.60	0.0	8806	7.9	259	13.76	6.45	6.99	21.00	Surface
	Fall					0.5	8813	8.0	261	13.77	6.30	6.98	20.97	
						1.0	8819	8.0	263	13.78	6.27	6.97	20.99	
						1.5	8813	7.9	264	13.77	6.28	6.97	20.93	
						2.0	8806	7.9	264	13.76	6.24	6.98	20.93	
						2.5	8813	7.9	265	13.77	6.29	6.98	20.93	
						3.0	8813	7.9	266	13.77	6.14	6.98	20.95	
						3.5	8813	7.9	267	13.77	6.17	6.98	20.95	
						4.0	8813	7.9	267	13.77	6.15	6.98	20.95	
						4.4	8813	7.9	268	13.77	6.13	6.98	20.96	Bottom

(1) Key to tidal stage codes: 1 = 1/4 ebb tide 2 = ½ ebb tide 3 = 3/4 ebb tide 4 = low tide 5 = 1/4 flood tide 6 = ½ flood tide 7 = 3/4 flood tide 8 = high tide

Table 1.1. (Continued)

Station	Date	Time (24-hour)	Tide Stage Code (1)	Air Temperature (Celsius)	Secchi Disk (meters)	Depth (meters)	Total Dissolved Solids (mg/L)	Salinity (ppt)	Oxidation Reduction Potential (millivolts)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH	Water Temperature (Celsius)	Remarks
CCWQ03	05/30/96	1550	3	21.6	0.40	0.0	559	0.5	386	0.87	7.17	7.42	20.38	Surface
College Creek	Spring					0.5	562	0.5	386	0.88	7.15	7.45	20.31	
(Lower)						1.0	561	0.5	387	0.88	7.14	7.45	20.31	
						1.5	562	0.5	387	0.88	7.19	7.46	20.36	
						2.0	561	0.5	387	0.88	7.20	7.46	20.40	
						2.5	561	0.5	388	0.88	7.18	7.45	20.38	
						3.0	559	0.5	388	0.87	7.10	7.45	20.33	
						3.5	560	0.5	389	0.88	7.05	7.45	20.31	
						4.0	559	0.5	389	0.87	7.11	7.45	20.31	
						4.5	554	0.5	390	0.87	6.99	7.42	20.24	
						5.0	559	0.5	390	0.87	6.93	7.42	20.19	
						5.5	558	0.5	390	0.87	6.91	7.42	20.24	
						6.0	559	0.5	391	0.87	6.94	7.42	20.22	
						6.5	561	0.5	391	0.88	6.94	7.43	20.22	
						7.0	560	0.5	391	0.88	6.92	7.42	20.17	
						7.5	568	0.5	391	0.89	6.92	7.43	20.19	
						8.0	570	0.5	392	0.89	6.89	7.43	20.19	Bottom
	10/02/95	1155	7	26.3	0.60	0.0	9792	8.9	248	15.30	7.63	7.15	21.91	Surface
	Fall					0.5	9792	8.9	251	15.30	7.42	7.11	21.74	
						1.0	9728	8.8	252	15.20	7.41	7.09	21.71	
						1.5	9728	8.8	254	15.20	7.14	7.08	21.69	
						2.0	9728	8.8	254	15.20	7.02	7.08	21.62	
						2.5	9728	8.8	256	15.20	7.01	7.07	21.66	
						3.0	9728	8.8	256	15.20	7.13	7.09	21.71	
						3.5	9664	8.8	257	15.10	7.13	7.08	21.67	
						4.0	9664	8.8	258	15.10	7.09	7.08	21.67	
						4.5	9664	8.9	259	15.10	7.07	7.08	21.66	
						5.0	9728	8.8	259	15.20	6.92	7.06	21.60	
						5.5	9728	8.8	261	15.20	6.93	7.06	21.60	
						6.0	9728	8.8	261	15.20	6.89	7.07	21.62	
						6.5	9728	8.8	262	15.20	6.91	7.06	21.64	
						6.9	9856	8.9	261	15.40	7.07	7.13	21.71	Bottom

(1) Key to tidal stage codes: 1 = 1/4 ebb tide 2 = ½ ebb tide 3 = 3/4 ebb tide 4 = low tide 5 = 1/4 flood tide 6 = ½ flood tide 7 = 3/4 flood tide 8 = high tide

Table 1.1. (Continued)

Station	Date	Time (24-hour)	Tide Stage Code (1)	Air Temperature (Celsius)	Secchi Disk (meters)	Depth (meters)	Total Dissolved Solids (mg/L)	Salinity (ppt)	Oxidation Reduction Potential (millivolts)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH	Water Temperature (Celsius)	Remarks
HCWQ01	05/30/96	1435	2	21.5	0.50	0.0	440	0.4	373	0.69	7.77	7.51	20.09	Surface
Halfway Creek	Spring					0.5	441	0.4	374	0.69	7.68	7.52	20.07	
(Upper)						1.0	441	0.4	375	0.69	7.62	7.52	20.03	
						1.5	440	0.4	376	0.69	7.62	7.52	20.03	Bottom
	10/02/95	1045	6	25.8	0.40	0.0	8397	7.5	336	13.12	6.69	7.05	21.09	Surface
	Fall					0.5	8397	7.5	336	13.12	6.42	7.03	21.07	
						1.0	8378	7.5	334	13.09	6.35	7.04	21.09	
						1.3	8435	7.6	332	13.18	6.35	7.03	21.09	Bottom
HCWQ02	05/30/96	1450	2	21.5	0.50	0.0	441	0.4	386	0.69	7.83	7.56	19.88	Surface
Halfway Creek	Spring					0.5	442	0.4	386	0.69	7.73	7.54	19.83	
(Upper trib)						1.0	442	0.4	386	0.69	7.66	7.54	19.81	Bottom
	10/02/95	1100	6	25.8	0.40	0.0	8365	7.5	302	13.07	6.13	6.95	20.69	Surface
	Fall					0.5	8333	7.5	302	13.02	5.71	6.93	20.64	
						1.0	8320	7.5	301	13.00	5.66	6.93	20.58	
						1.5	8333	7.5	300	13.02	5.56	6.93	20.57	Bottom
HCWQ03	05/30/96	1500	2	21.5	0.50	0.0	445	0.4	370	0.70	7.62	7.50	19.98	Surface
Halfway Creek	Spring					0.5	446	0.4	375	0.70	7.56	7.49	19.98	
(Lower)						1.0	446	0.4	376	0.70	7.54	7.49	19.96	
						1.5	446	0.4	376	0.70	7.50	7.49	19.96	
						1.9	446	0.4	377	0.70	7.50	7.49	19.96	Bottom
	10/02/95	1110	7	25.8	0.50	0.0	8544	7.7	276	13.35	6.15	6.94	20.79	Surface
	Fall					0.5	8538	7.7	277	13.34	6.05	6.94	20.78	
						1.0	8544	7.7	277	13.35	5.88	6.94	20.78	
						1.5	8550	7.7	278	13.36	5.78	6.94	20.76	
						2.0	8550	7.7	275	13.36	5.65	6.94	20.76	Bottom
SPWQ01	05/29/96	1400	2	18.6	0.45	0.0	228	0.2	387	0.36	5.63	7.15	18.14	Surface
Black Duck Gut	Spring					0.5	227	0.2	386	0.35	4.83	7.09	18.12	
(Upper)						1.0	228	0.2	385	0.36	4.79	7.08	18.12	Bottom
	09/27/95	1515	5	29.4	0.60	0.0	6925	6.2	312	10.82	9.04	7.60	23.16	Surface
	Fall					0.5	6957	6.2	310	10.87	9.36	7.64	22.15	
						1.0	6957	6.2	310	10.87	9.15	7.63	22.05	Bottom

(1) Key to tidal stage codes: 1 = 1/4 ebb tide 2 = ½ ebb tide 3 = 3/4 ebb tide 4 = low tide 5 = 1/4 flood tide 6 = ½ flood tide 7 = 3/4 flood tide 8 = high tide

Table 1.1. (Continued)

Station	Date	Time (24-hour)	Tide Stage Code (1)	Air Temperature (Celsius)	Secchi Disk (meters)	Depth (meters)	Total Dissolved Solids (mg/L)	Salinity (ppt)	Oxidation Reduction Potential (millivolts)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH	Water Temperature (Celsius)	Remarks
SPWQ02	05/29/96	1430	3	18.6	0.60	0.0	209	0.2	393	0.33	5.15	7.17	18.53	Surface
Black Duck Gut	Spring					0.5	210	0.2	396	0.33	5.04	7.12	18.55	
(Lower)						1.0	211	0.2	395	0.33	4.93	7.11	18.52	
						1.2	212	0.2	395	0.33	4.91	7.09	18.52	Bottom
	09/27/95	1530	5	29.7	0.60	0.0	7443	6.7	277	11.63	9.18	7.78	22.24	Surface
	Fall					0.5	7462	6.7	279	11.66	9.10	7.77	22.28	
						1.0	7456	6.6	276	11.65	9.46	7.80	22.19	
						1.5	7462	6.6	276	11.66	9.21	7.81	22.19	
						1.7	7462	6.6	276	11.66	9.08	7.81	22.17	Bottom
SPWQ03	05/29/96	1500	3	18.5	0.60	0.0	216	0.2	362	0.34	7.50	7.83	20.38	Surface
James River	Spring					0.5	216	0.2	363	0.34	7.42	7.82	20.38	
						1.0	213	0.2	364	0.33	7.32	7.82	20.38	Bottom
	09/27/95	1600	5	30.1	0.80	0.0	7904	7.1	271	12.35	9.82	7.92	22.71	Surface
	Fall					0.5	7917	7.1	270	12.37	9.56	7.96	22.69	
						1.0	7930	7.1	269	12.39	9.29	7.98	22.69	
						1.5	7955	7.1	268	12.43	9.67	7.99	22.63	Bottom

(1) Key to tidal stage codes: 1 = 1/4 ebb tide 2 = ½ ebb tide 3 = 3/4 ebb tide 4 = low tide 5 = 1/4 flood tide 6 = ½ flood tide 7 = 3/4 flood tide 8 = high tide

Table 1.2. Numbers and size (total lengths in mm) ranges (in parentheses) of fishes captured during surveys of waters bordering Swann's Point, and along College Creek and Halfway Creek in the Kingsmill Neck area, in September-October 1995 (Fall) and May 1996 (Spring

Species	Swann's Point		College Creek		Halfway Creek		Species Total
	Fall	Spring	Fall	Spring	Fall	Spring	
Longnose gar	-	-	-	1	2	1	4
Lepisosteus osseus	-	-	-	(970)	(704-774)	(805)	(704-970)
Bowfin	-	1	-	-	-	-	1
Amia calva	-	(735)	-	-	-	-	(735)
American eel	-	1	4	3	1	-	9
Anguilla rostrata	-	(570)	(475-610)	(494-625)	(403)	-	(403-625)
American shad	-	-	-	1	-	-	1
Alosa sapidissima	-	-	-	(75)	-	-	(75)
Atlantic menhaden	8	486	6	20	1	-	521
Brevoortia tyrannus	(182-236)	(39-260)	(183-238)	(38-64)	(126)	-	(39-260)
Gizzard shad	57	70	27	87	61	80	382
Dorosoma cepedianum	(163-406)	(220-395)	(230-428)	(160-420)	(134-385)	(171-385)	(134-428)
Threadfin shad	3	-	-	-	1	-	4
Dorosoma petenense	(114-139)	-	-	-	(112)	-	(112-139)
Bay anchovy	5	9	131	101	-	-	246
Anchoa mitchilli	(39-105)	(38-57)	(36-72)	(30-74)	-	-	(30-105)
Common carp	-	-	-	4	1	2	7
Cyprinus carpio	-	-	-	(450-758)	(541)	(520-585)	(450-758)
Eastern silvery minnow	-	9	-	-	-	-	9
Hybognathus regius	-	(93-110)	-	-	-	-	(93-110)
Golden shiner	-	19	-	-	1	-	20
Notemigonus crysoleucas	-	(86-180)	-	-	(155)	-	(86-180)
Spottail shiner	3	23	-	-	-	-	26
Notropis hudsonius	(102-106)	(103-123)	-	-	-	-	(102-123)
White catfish	2	7	-	1	-	3	13
Ameiurus catus	(111-173)	(237-290)	-	(201)	-	(263-275)	(111-290)
Brown bullhead	-	1	-	-	-	-	1
Ameiurus nebulosus	-	(305)	-	-	-	-	(305)
Blue catfish	-	1	3	42	-	11	57
Ictalurus furcatus	-	(261)	(131-159)	(120-454)	-	(256-402)	(120-454)
Channel catfish	2	11	1	8	3	5	30
Ictalurus punctatus	(348-419)	(340-455)	(480)	(128-548)	(350-410)	(369-635)	(128-635)
Atlantic needlefish	-	3	-	-	-	-	3
Strongylura marina	-	(364-395)	-	-	-	-	(364-395)
Mummichog	45	13	198	22	134	90	502
Fundulus heteroclitus	(27-82)	(32-63)	(30-82)	(42-101)	(33-80)	(40-85)	(27-101)
Eastern mosquitofish	-	-	18	-	7	-	25
Gambusia holbrooki	-	-	(32-45)	-	(30-39)	-	(30-45)
Rough silverside	12	32	3	19	-	-	66
Membras martinica	(49-83)	(68-106)	(45-48)	(71-99)	-	-	(45-106)
Inland silverside	184	26	199	9	1	-	419

Menidia beryllina	(49-89)	(55-72)	(31-83)	(53-73)	(51)	-	(31-89)
White perch Morone americana	93 (65-251)	156 (72-233)	81 (60-222)	104 (73-269)	32 (67-247)	45 (90-275)	511 (60-275)
Striped bass Morone saxatilis	7 (86-709)	5 (233-419)	27 (76-462)	- -	1 (323)	- -	40 (76-709)
Pumpkinseed Lepomis gibbosus	- -	2 (72-90)	- -	2 (93-109)	- -	1 (159)	5 (72-159)
Bluegill Lepomis macrochirus	- -	4 (73-175)	1 (177)	- -	3 (136-161)	2 (158-177)	10 (73-177)
Species	Swann's Fall	Point Spring	College Fall	Creek Spring	Halfway Fall	Creek Spring	Species Total
Largemouth bass Micropterus salmoides	1 (354)	- -	- -	- -	5 (163-388)	2 (340-380)	8 (163-388)
Black crappie Pomoxis nigromaculatus	- -	- -	- -	- -	- -	4 (261-315)	4 (261-315)
Yellow perch Perca flavescens	- -	- -	- -	- -	- -	1 (186)	1 (186)
Silver perch Bairdiella chrysoura	2 (162-165)	- -	1 (133)	- -	1 (134)	- -	4 (133-165)
Weakfish Cynoscion regalis	- -	- -	1 (151)	- -	- -	- -	1 (151)
Spot Leiostomus xanthurus	7 (173-188)	- -	2 (134-154)	- -	7 (128-155)	- -	16 (128-188)
Atlantic croaker Micropogonias undulatus	3 (154-188)	- -	1 (40)	- -	- -	- -	4 (40-188)
Striped mullet Mugil cephalus	11 (233-292)	- -	2 (238-304)	- -	1 (272)	- -	14 (233-304)
Goby Gobiosoma sp. [1]	- -	- -	8 (39-45)	- -	8 (38-43)	- -	16 (38-45)
Southern flounder Paralichthys lethostigma	- -	- -	1 (351)	- -	- -	- -	1 (351)
Hogchoker Trinectes maculatus	2 (91-112)	14 (29-96)	9 (40-89)	49 (42-105)	- -	3 (45-88)	77 (29-112)
Total	447	893	724	473	271	250	3,058

[1] Could not identify to species with the key available. The specimens had characteristics of both the naked goby (*Gobiosoma bosc*) and the seaboard goby (*Gobiosoma ginsburgi*).

Table 1.3. Origination, migratory nature and life stages of fish occurring in waters bordering Swann's Point and in the Kingsmill Neck area

Species	Species' Origination		Migratory Nature		Life Stage		Use
	Native	Exotic	Non-migratory	Migratory	Spawning	Larval/Juvenile	Adult
Longnose gar Lepisosteus osseus	X		X		X	X	X
Bowfin Amia calva	X		X		? (9)	X	X
American eel Anguilla rostrata	X			X (2)		X	X
American shad Alosa sapidissima	X			X (3)	? (10)	X	X
Atlantic menhaden Brevoortia tyrannus	X			X (4)		X	X
Gizzard shad Dorosoma cepedianum	X		X		? (10)	X	X
Threadfin shad Dorosoma petenense	X (1)		X		? (10)	X	X
Bay anchovy Anchoa mitchilli	X		X		X	X	X
Common carp Cyprinus carpio		X	X		? (10)	X	X
Eastern silvery minnow Hybognathus regius	X		X		? (9)	X	X
Golden shiner Notemigonus crysoleucas	X		X		? (9)	X	X
Spottail shiner Notropis hudsonius	X		X		? (9)	X	X
White catfish Ameiurus catus	X		X		? (9)	X	X
Brown bullhead Ameiurus nebulosus	X		X		? (9)	X	X
Blue catfish Ictalurus furcatus	X (1)		X		? (9)	X	X

(1) Native to North America but introduced to this drainage.

(2) Catadromous species.

(3) Anadromous species.

(4) Adults overwinter and spawn in the Atlantic Ocean.

(5) Adults overwinter in the lower Chesapeake Bay and/or Atlantic Ocean.

(6) Spawning likely occurs farther downstream in the James River.

(7) Semi-anadromous; adults prefer brackish water for most of the year but migrate to freshwater to spawn.

(8) Adults overwinter and spawn in the lower Chesapeake Bay and Atlantic Ocean.

(9) Spawning is likely to occur in waters bordering COLO.

(10) Some spawning may occur in the area, but the primary spawning grounds are farther up the James River or tributaries.

(11) Adults tend to inhabit waters farther downstream in the estuary.

(12) This species is typically found in estuaries south of Virginia; adults are rare visitors to the Chesapeake Bay.

Species	Native	Exotic	Non-migratory	Migratory	Spawning	Larval/Juvenile	Adult
Channel catfish Ictalurus punctatus	X (1)		X		? (9)	X	X
Atlantic needlefish Strongylura marina	X			X (5)	X	X	X
Mummichog Fundulus heteroclitus	X		X		X	X	X
Eastern mosquitofish Gambusia holbrooki	X		X		X	X	X
Rough silverside Membras martinica	X			X (5)(6)		X	X
Inland silverside Menidia beryllina	X		X		X	X	X
White perch Morone americana	X			X (7)		X	X
Striped bass Morone saxatilis	X			X (3)	? (10)	X	X
Pumpkinseed Lepomis gibbosus	X		X		? (9)	X	X
Bluegill Lepomis macrochirus	X (1)		X		? (9)	X	X
Largemouth bass Micropterus salmoides	X (1)		X		? (9)	X	X
Black crappie Pomoxis nigromaculatus	X		X		? (9)	X	X
Yellow perch Perca flavescens	X		X		? (9)	X	X
Silver perch Bairdiella chrysoura	X			X (8)		X	X
Weakfish Cynoscion regalis	X			X (8)		X	? (11)

(1) Native to North America but introduced to this drainage.

(2) Catadromous species.

(3) Anadromous species.

(4) Adults overwinter and spawn in the Atlantic Ocean.

(5) Adults overwinter in the lower Chesapeake Bay and/or Atlantic Ocean.

(6) Spawning likely occurs farther downstream in the James River.

(7) Semi-anadromous; adults prefer brackish water for most of the year but migrate to freshwater to spawn.

(8) Adults overwinter and spawn in the lower Chesapeake Bay and Atlantic Ocean.

(9) Spawning is likely to occur in waters bordering COLO.

(10) Some spawning may occur in the area, but the primary spawning grounds are farther up the James River or tributaries.

(11) Adults tend to inhabit waters farther downstream in the estuary.

(12) This species is typically found in estuaries south of Virginia; adults are rare visitors to the Chesapeake Bay.

Table 1.3. (Continued)

Species	Native	Exotic	Non-migratory	Migratory	Spawning	Larval/Juvenile	Adult
Spot Leiostomus xanthurus	X			X (4)		X	? (11)
Atlantic croaker Micropogonias undulatus	X			X (4)		X	? (11)
Striped mullet Mugil cephalus	X			X (4)		X	X
Goby Gobiosoma sp. *	X		X		X	X	X
Southern flounder Paralichthys lethostigma	X			X (4)			X (12)
Hogchoker Trinectes maculatus	X		X		X	X	X

(1) Native to North America but introduced to this drainage.

(2) Catadromous species.

(3) Anadromous species.

(4) Adults overwinter and spawn in the Atlantic Ocean.

(5) Adults overwinter in the lower Chesapeake Bay and/or Atlantic Ocean.

(6) Spawning likely occurs farther downstream in the James River.

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(11) Adults tend to inhabit waters farther downstream in the estuary.

(12) This species is typically found in estuaries south of Virginia; adults are rare visitors to the Chesapeake Bay.

Part II: Wormley Pond

Study Area

Wormley Pond is a shallow, nontidal, spring-fed, freshwater impoundment located on the eastern side of the Yorktown Unit of COLO, in York County, Virginia. This impoundment is predominantly open-water habitat, but the upper areas of the pond "arms" are shallow and support dense beds of submerged aquatic vegetation (SAV) dominated by coontail (*Ceratophyllum demersum*). A maximum water depth of 1.5 m occurs near the pond dam. This pond is not open to the public for recreational fishing.

Methods

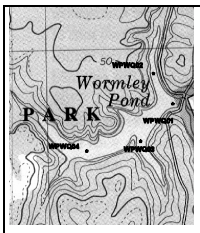
The fish community of Wormley Pond was sampled once on 30 August 1994 using an electrofishing boat and pulsed DC current. As the fish community of this impoundment would not exhibit seasonal changes, this one sample was deemed adequate. Very shallow water and abundant SAV prevented sampling of the upper portion of the pond, but otherwise the electrofishing boat effectively covered the impoundment during one hour of sampling. All largemouth bass, and a subsample of the bluegill, were dipnetted, weighed, and total length (TL) measured. The dipnetting of all the bluegill observed was neither practical nor possible. Other fish species observed were noted.

Relative weights were calculated for the individual largemouth bass and bluegill that were weighed and measured. Relative weight (W_r) is a common index of fish health/quality that may be calculated from the length and weight variables of a fish (Nielsen and Johnson 1983). Fish with W_r values near 100 are considered to be in balance with their food supply. Fish with values below 85 are underweight, indicating that they may be overabundant relative to their food supply. Conversely, fish with values exceeding 105 are very well-fed and likely indicate an overabundance of forage available to them.

Water quality parameters for salinity, oxidation reduction potential, conductivity, dissolved oxygen, pH, and water temperature were measured from the bottom to the surface at 0.3-meter intervals with a Hydrolab Surveyor II water quality meter on 11 July 1997 between 0930-1030 hours. Water quality profile measurements were made at four locations in the pond (Figure 2.1).

Results

For the most part, the water quality in Wormley Pond is typical for ponds of eastern Virginia (Table 2.1). The pH (median observed value of 7.42) is higher than many coastal plain ponds, probably as a result of the fossiliferous soils (Yorktown formation) found in the Yorktown area.



***** = Water quality sampling station

Figure 2.1. Water quality stations sampled on 11 July 1997 at Wormley Pond

Table 2.1. Water quality values measured in Wormley Pond on 11 July 1997

Station	Date	Time (24-hour)	Secchi Disk (meters)	Depth (meters)	Dissolved Solids (mg/L)	Salinity (ppt)	Reduction Potential (millivolts)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH	Water Temperature (Celsius)	Remarks
WPWQ01	07/11/97	930	1.20	0.0	275	0.0	277	0.430	9.7	7.25	27.69	Surface
				0.3	246	0.0	245	0.385	8.9	7.42	27.77	
				0.6	246	0.0	233	0.384	7.3	7.41	27.56	
				0.9	248	0.0	195	0.388	5.7	7.36	27.50	
				1.2	252	0.0	117	0.394	3.2	7.23	27.36	
				1.5	285	0.0	86	0.445	1.3	7.10	27.02	Bottom
WPWQ02	07/11/97	1015	1.20	0.0	235	0.0	267	0.367	8.7	7.52	27.91	Surface
				0.3	228	0.0	252	0.356	6.9	7.61	27.72	
				0.6	220	0.0	246	0.344	5.7	7.70	27.18	
				0.9	221	0.0	221	0.345	4.8	7.71	27.12	
				1.2	223	0.0	198	0.348	1.9	7.66	26.61	Bottom
WPWQ03	07/11/97	945	1.20	0.0	238	0.0	308	0.372	9.2	7.46	27.61	Surface
				0.3	238	0.0	306	0.372	7.9	7.45	27.61	
				0.6	237	0.0	305	0.371	7.2	7.42	27.58	
				0.9	238	0.0	299	0.372	5.3	7.42	27.52	
				1.2	236	0.0	297	0.369	1.8	7.45	27.42	Bottom
WPWQ04	07/11/97	1000	1.20	0.0	236	0.0	294	0.368	9.3	7.53	27.33	Surface
				0.3	236	0.0	291	0.368	8.0	7.54	27.33	
				0.6	235	0.0	279	0.367	6.9	7.53	27.33	
				0.9	235	0.0	270	0.367	5.2	7.51	27.24	
				1.2	275	0.0	268	0.429	2.6	7.37	25.90	Bottom

Due to being relatively shallow, the water temperature throughout the pond was warm and fairly uniforms (25.90 - 27.91 C). Dissolved oxygen levels in the upper meter of the water column appear more than adequate for fish, but benthic decomposition of organic matter reduces available oxygen closer to the bottom during summer months; a common phenomenon in warmwater impoundments in Virginia.

Wormley Pond supports a relatively diverse community of six common fishes (Table 2.2) including American eel (*Anguilla rostrata*), golden shiner (*Notemigonus crysoleucas*), eastern mosquitofish (*Gambusia holbrooki*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*). All species are abundant, with the exception of pumpkinseed (only two pumpkinseed were observed). While all six species are native to North America (Table 2.3), the bluegill and largemouth bass have been introduced to eastern Virginia within the last 150 years (Jenkins and Burkhead 1993). None of the fishes captured in this survey are listed as threatened, endangered, or candidate species by either the USFWS or Virginia Department of Game and Inland Fisheries.

The American eel is the only species present in Wormley Pond that is not a life-long resident (Table 2.3). The commercially-important American eel has a catadromous life cycle. Adult eels spawn at sea and the young migrate to freshwater/estuarine habitats in the spring where they spend most of their life growing to maturity. The young eels are very adept at ascending low-head dams in search of suitable freshwater habitat. As a result, American eels are commonly found in small impoundments throughout Virginia.

A total of 87 largemouth bass were captured, of which 33 were immature (<200 mm TL), 53 were of stock size (200-299 mm TL) and one was of quality size (300-379 mm TL). Based on this sample, the largemouth bass population in Wormley Pond is very dense compared to other impoundments in Virginia, and dominated by stunted individuals in the stock size category. This observation is corroborated by a median relative weight (W_r) of 84 for stock-sized largemouth bass, indicating the bass are having difficulty finding enough to eat. As Wormley Pond is not open to recreational anglers, this overabundance and stunting is of minor significance as the largemouth bass continue to be of ecological importance as predators, as well as prey for avian and mammalian predators (otters, osprey, herons, etc.).

Bluegill appears relatively abundant with a typical mix of stock (80-149 mm TL) and quality (150-199 mm TL) sizes in the population. However, the relative weights of the bluegill tended to be low (median $W_r = 87$), possibly due to interspecific competition with the over-abundant and stunted largemouth bass.

In summary, Wormley Pond is a typical, shallow, freshwater impoundment supporting a relatively diverse community of six common native fish species with significant ecological value. It provides useful juvenile habitat for American eel, an interjurisdictional fishery resource of national significance. The bluegill population is average by Virginia standards, though the individual fish tend to be thin. The largemouth bass are exceptionally abundant and stunted. Since this pond is not open to recreational anglers, this imbalance between predator and prey and its resultant stunting of the individual fish is of minor importance; the

fish of Wormley Pond continue to be of significant ecological importance in recycling energy and nutrients, and providing food to avian and mammalian predators.

Table 2.2. Numbers and size (total lengths in mm) ranges (in parentheses) of fishes captured during a survey of Wormley Pond on 30 August 1994.

Species	Number Collected	Size Range (Total length in mm)
American eel Anguilla rostrata	Many*	-
Golden shiner Notemigonus crysoleucas	Many	-
Eastern mosquitofish Gambusia holbrooki	Many	-
Pumpkinseed Lepomis gibbosus	2	147-164
Bluegill Lepomis macrochirus	31**	41-194
Largemouth bass Micropterus salmoides	87	78-313

* Many individuals observed but not enumerated.

** This is a subsample; many more individuals were observed but not enumerated.

Table 2.3. Origination, migratory nature, and life stages of fishes occurring in Wormley Pond.

Species	Species' Native	Origination Exotic	Migratory Non-migratory	Nature Migratory	Life Spawning	Stage Larval/Juvenile	Use Adult
American eel Anguilla rostrata	X			X (1)		X	X
Golden shiner Notemigonus crysoleucas	X		X		X	X	X
Eastern mosquitofish Gambusia holbrooki	X		X		X	X	X
Pumpkinseed Lepomis gibbosus	X		X		X	X	X
Bluegill Lepomis macrochirus	X (2)		X		X	X	X
Largemouth bass Micropterus salmoides	X (2)		X		X	X	X

(1) Catadromous species.

(2) Native to North America but introduced to this drainage.

Recommendations

Baseline water quality and fisheries resources should be resurveyed on a ten-year rotational basis throughout COLO; a level of monitoring that would be adequate for most water bodies within the park. A more frequent sampling schedule (five-year rotational basis) may be desirable for water bodies that may be prone to significant degradation from land-use outside the park, or for impoundments that experience significant angler use. On water bodies prone to degradation, COLO should consider intensifying water quality monitoring efforts to document nutrient levels and sources.

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